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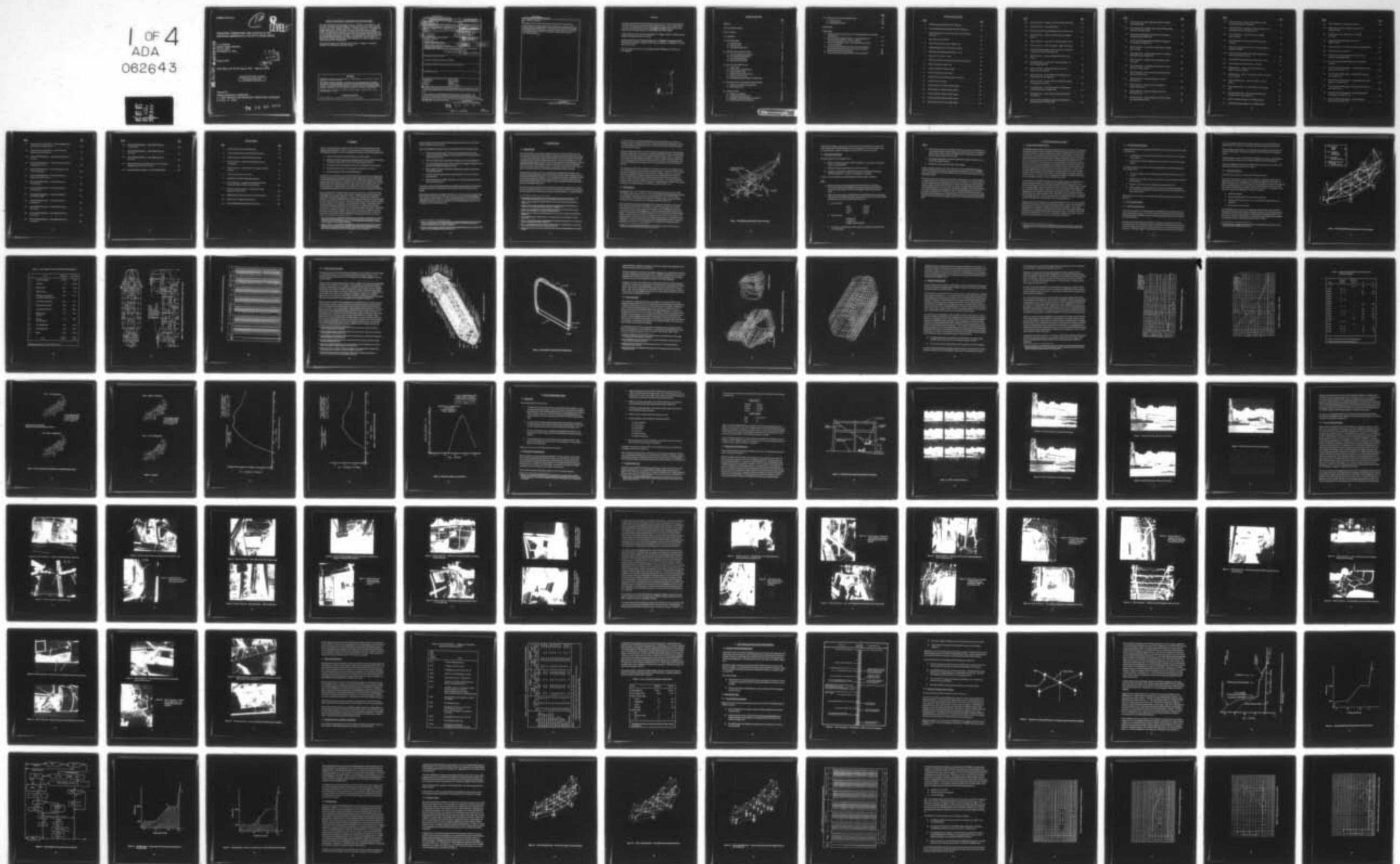

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LEVEL II

SIMULATION, CORRELATION, AND ANALYSIS OF THE STRUCTURAL RESPONSE OF A CH-47A TO CRASH IMPACT

Y. V. BadriNath
BOEING VERTOL COMPANY
P.O. Box 16858
Philadelphia, Pa. 19142

August 1978

Final Report for Period March 1976 - February 1978

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Prepared for

APPLIED TECHNOLOGY LABORATORY
U. S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES (AVRADCOM)
Fort Eustis, Va. 23604

APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

This report was prepared by the Boeing Vertol Co., a Division of the Boeing Co., under the terms of Contract DAAJ02-76-C-0015. The objective of this effort was to achieve structural crash impact simulation technology. This was achieved by: (1) simulating the dynamic response of a CH-47A helicopter to crash impact using computer program KRASH; (2) correlating the predictions of KRASH with Government-furnished data from a joint ATL/NASA CH-47A crash test performed at NASA-Langley Research Center; and (3) recommending improvements to KRASH. Concurrent with the effort described herein, the Lockheed-California Company has revised the USAAMRDL TR74-12 version of KRASH and simulated light fixed-wing aircraft crashes for the Federal Aviation Administration (Contract DOT-FA75-WA-3707).

The technical manager for this program was Mr. George T. Singley, III, Structures Technical Area, Aeronautical Technology Division.

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The purpose of this effort was to model the dynamic response of the CH-47A helicopter to a crash impact using program KRASH and to correlate the results with data from a CH-47A crash impact test.

An improved version of KRASH developed at Boeing Vertol was used for this purpose. This report contains details of the development of a CH-47A KRASH structural model, the pretest predictions, and the description of the CH-47A crash impact test together with test data. Post-test

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20. ABSTRACT – Continued

improvements to the structural model to improve correlation with test data are discussed.

Problems related to the computer program which arose during the course of the simulation and correlation efforts are discussed in detail. It is concluded that the use of KRASH for simulation of the dynamic response of helicopters to crash impact is currently limited. It is recommended that KRASH be improved in order for it to be useful as a design tool for the analysis of structural crashworthiness.

PREFACE

This report was prepared by the Boeing Vertol Company under U.S. Army Contract DAAJ02-76-C-0015. The contract was performed during the period of March 1976 through February 1978 under the administrative direction of the Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia.

Technical direction for the project was provided by G. T. Singley, III and L. T. Burrows of the Applied Technology Laboratory, Fort Eustis.

The Boeing Vertol Company Program Manager was Y. V. BadriNath. Test support, CH-47A KRASH model development, simulation, and correlation studies were conducted by Y. V. Badri-Nath and J. R. Nicely.

Other contributors to the success of the program included E. Widmayer, L. Norton, and H. Wohlgemuth.

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1.0 SUMMARY

As part of a continuing effort to advance the state of the art in aircraft crashworthiness, the Applied Technology Laboratory (ATL), U.S. Army Research and Technology Laboratories (AVRADCOM), awarded a contract to the Boeing Vertol Company with the following basic tasks:

- Develop a math model of the CH-47A helicopter crashworthiness.
- Simulate the model using the Army-developed computer program KRASH and predict the dynamic response of the airframe under defined impact conditions.
- Incorporate previously defined improvements into the KRASH computer program.
- Correlate analytical results of the simulation with full-scale crash test data.
- Recommend improvements to the KRASH program.

During the course of this project, a full-scale CH-47A helicopter crash impact test was performed at the National Aeronautics and Space Administration's Langley Research Center (NASA/LRC) by ATL and NASA/LRC personnel. The impact condition was planned to represent a nose-down, 95th percentile, rotary-wing aircraft survivable crash accident with the resultant contact velocity equal to 50 fps. The test aircraft contained two cargo restraint system experiments and a crew restraint experiment. One hundred twenty-five channels of test data were acquired through a comprehensive data acquisition system. Internal and external movie coverage was also provided.

Prior to the actual test, a structural model of the proposed test article, consisting of 36 masses and 84 beam elements, was developed for simulation on KRASH. The initial development of the KRASH code is described in Reference 1. A later version, KRASH III, documented in Reference 2, was further modified by Boeing Vertol during the performance of contract DAAJ02-75-C-0014 and is referred to as S-7900. The structural model was simulated on S-7900 to predict the dynamic response of the airframe to the planned impact condition. The predictions were used for pretest planning. Subsequent to the crash impact test at NASA/LRC, preliminary correlations of the analytical predictions with test data indicated gross discrepancies. The pretest model was then modified to represent more accurately the test article configuration and was simulated for the test impact condition. Based on the results of this simulation, several refinements were incorporated into the CH-47A KRASH model during successive runs in order to

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1. Wittlin, G., and Gamon, M. A., EXPERIMENTAL PROGRAM FOR THE DEVELOPMENT OF IMPROVED HELICOPTER STRUCTURAL CRASHWORTHINESS ANALYTICAL AND DESIGN TECHNIQUES, Lockhead-California Company, USAAMRDL TR72-72A, TR72-72B, Eustis Directorate, U. S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, May 1973, AD764985 and AD764986.
2. Wittlin, G., and Park, K.C., DEVELOPMENT AND EXPERIMENTAL VERIFICATION PROCEDURES TO DETERMINE NONLINEAR LOAD-DEFLECTION CHARACTERISTICS OF HELICOPTER SUBSTRUCTURES SUBJECTED TO CRASH FORCES, Lockheed-California Company, USAAMRDL TR74-12A, TR74-12B, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, AD784191 and AD784192.

obtain an improved correlation between analytical predictions and test data. These efforts resulted in a limited amount of success.

Some of the KRASH code limitations and errors which prevented closer correlations were:

- Insufficient permissible number of elements and associated masses to suitably represent the structural configuration and mass distribution of a large aircraft such as the CH-47A test article.
- The element library does not allow proper modeling of an oleo-type landing gear.
- The external spring element logic represents behavior of frangible/crushable structure properly only during the primary power stroke.
- Overly simplified treatment of structural nonlinearities resulting in negative strain energy being computed.
- The code cannot successfully analyze vehicle dynamics in the case of successive/multiple impacts.
- Basic coding errors in the DERIV subroutine. Some of these errors have since been corrected (see Reference 3).

This report contains details of the simulation and correlation studies together with discussions of those shortcomings in the KRASH code which affected achieving the objectives of the program.

Certain improvements previously defined in Reference 4, as well as corrections to program logic found necessary during the course of this task, were incorporated into the KRASH program under a separate contract, Reference 3. Recommendations for additional improvements and modifications required to enhance the capabilities of the KRASH program and permit its use as a design tool are included in this report.

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3. Tanner, A. E., and Widmayer, E., HELICOPTER STRUCTURAL CRASHWORTHINESS SIMULATION AND ANALYSIS, Boeing Vertol Company, USARTL-78-21, Applied Technology Laboratory, U.S. Army Research and Development Laboratories (AVRADCOM), Fort Eustis, Virginia, to be published.

4. PROPOSAL FOR MATHEMATICAL MODEL (KRASH) OF CH-46 CRASHWORTHINESS, Boeing Document D210-11010-1, Boeing Vertol Company, Philadelphia, Pennsylvania, December 1975.

2.0 INTRODUCTION

2.1 BACKGROUND

Since the mid 1940's, several major investigations have been conducted into the nature and characteristics of crash impacts involving rotary- and fixed-wing aircraft (References 5 through 12). The studies indicate that in many of these accidents many of the occupants of the aircraft would have survived if crash survivability had been part of the air vehicle design criteria. The Applied Technology Laboratory (ATL) of the U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia, a pioneer in these efforts, has conducted 40 full-scale crash tests of various aircraft as well as tests on several major components during the course of research activity directed toward understanding and defining the crash environment.

These experimental and research efforts culminated in the establishment of design and test criteria for incorporating crashworthiness into helicopter airframes. Relevant design criteria are specified in MIL-STD-1290, Reference 13. Data on potentially survivable crash impact velocities and accelerations applicable to different classes of aircraft, e.g., helicopters, light fixed-wing aircraft and fixed-wing transport aircraft, together with recommended crashworthiness design practices are provided in Reference 5.

In order to meet these requirements, the aircraft structure shall be so designed that, in a 95th-percentile survivable crash impact, the structural envelope for passengers and crew shall attenuate the crash impulse loads to within human tolerance levels and maintain, by a controlled collapse

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5. CRASH SURVIVAL DESIGN GUIDE, Dynamic Science,USAAMRDL TR71-22, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, Revised October 1971, AD733358.
6. Greer, D. L., et al, CRASHWORTHY DESIGN PRINCIPLES, FAA TR ADS-24, Federal Aviation Administration, Washington, D.C.
7. Reed, W. H., et al, FULL SCALE DYNAMIC CRASH TEST OF A LOCKHEED CONSTELLATION MODEL 1649 AIRCRAFT, FAA TR ADS-38, Federal Aviation Administration, Washington, D.C.
8. Turnbow, J. W., A DYNAMIC TEST OF AN H-25 HELICOPTER, SAE Report 517A, National Aerostatic Meeting, Society of Automotive Engineers, Inc., Warrendale, Pennsylvania, April 1972.
9. Fitzgibbon, D. P., et al, CRASH LOADS ENVIRONMENT STUDY, FAA TR DS 67-2, Federal Aviation Administration, Washington, D.C.
10. UH-1 ACCIDENT SUMMARY, USABAAR Report, U.S. Army Board for Aviation Accident Research, Fort Rucker, Alabama, 1963.
11. Mattox, K. L., INJURY-EXPERIENCE IN ARMY HELICOPTER ACCIDENTS, USABAAR Report, U.S. Army Board for Aviation Accident Research, Fort Rucker, Alabama, 1967.
12. Haley, J. L., HELICOPTER STRUCTURAL DESIGN FOR IMPACT SURVIVAL, USABAAR Report, U.S. Army Board for Aviation Accident Research, Fort Rucker, Alabama, November 1970.
13. Military Standard 1290(AV), LIGHT FIXED AND ROTARY WING AIRCRAFT CRASHWORTHINESS, U.S. Department of Defense.

of structural elements, a minimum inhabitable volume in the occupied areas. Further, it is necessary to prevent mechanical injury to the occupants resulting from foreign objects such as rotor blade fragments, crash debris, and heavy concentrated masses penetrating the occupied areas during the crash impact.

It became evident that in order to be able to incorporate crashworthiness into airframes during preliminary design stages, an analytical tool capable of predicting the nonlinear time-dependent responses of structural elements to crash-induced loads was necessary. This led to the development of several computer programs based upon a macrofinite element approach. Perhaps the most reliable of these for the analysis of airframe structural response under crash impact conditions is the KRASH program developed under ATL sponsorship by the Lockheed-California Company.

The mathematical model of the aircraft used in the analysis consists of a set of lumped masses connected by beam type structural elements as shown in Figure 1. Equations of motion relating the acceleration and velocities of each mass to the forces of deformation of the connecting elements are established. Nonlinear structural behavior and element rupture are taken into account. Initial conditions, namely translational and rotational velocities and attitudes, are utilized to obtain time history solutions to the equations of motion. The actual computations are performed using numerical analysis techniques on a digital computer. Details of the analytical development, the program listing, and the validation are found in Reference 1.

2.2 TEST ARTICLE

During March 1975, a CH-47C helicopter with several onboard experiments was crash tested at the NASA/Langley Research Center. The test provided valuable data regarding the performance of several types of crash-attenuating crew/troop seat installations as well as on the overall structural behavior of the airframe when subjected to a 95th-percentile, nose-up crash impact. Full details of the test conditions and test results are reported in Reference 14.

Hence, during the initial stage of this program, ATL investigated the possibility of using a different helicopter model currently in the military inventory for crash testing. The U.S. Navy expressed some interest in crash testing a CH-46 aircraft, as the knowledge gained from such a test would also be of use for fleet applications. A YHC-1A airframe was made available for this purpose. It was thought that this airframe was identical in structural arrangement with the CH-46 airframes currently in the U.S. Navy and U.S. Marine inventory. However, an inspection of the supplied airframe revealed that its structure was highly nonrepresentative of the CH-46 structural configuration. As such, any data obtained from crash testing this specific airframe would not be of significant use. Therefore, it was concluded that an available CH-47A airframe should be

14. Singley, G.T., III, FULL-SCALE CRASH TESTING OF A CH-47C HELICOPTER, Paper Number 1082, 32nd Annual National Forum, American Helicopter Society, Washington, D.C., May 1976.

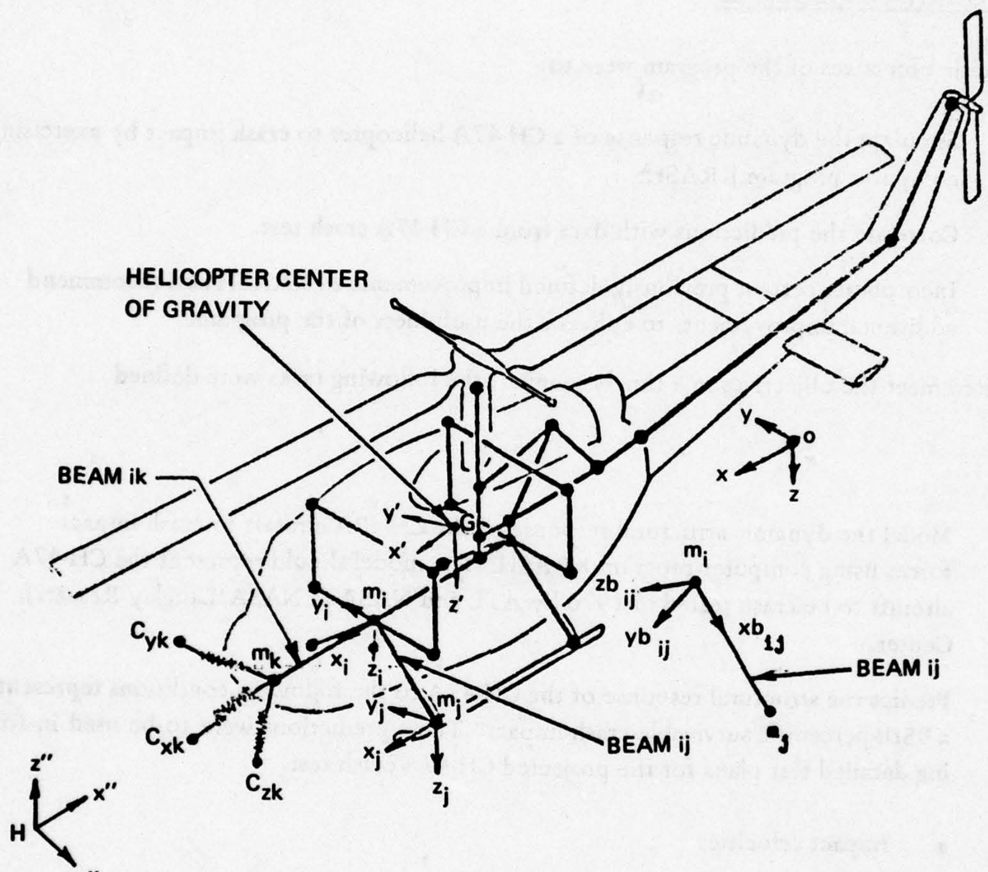

Figure 1. KRASH Mathematical Model of UH-1 Helicopter.

utilized for this program. The test article would carry several onboard U.S. Army cargo experiments together with an NADC-developed crew restraint experiment. Further, the impact conditions were selected to represent a 95th-percentile, survivable, nose-down crash impact.

2.3 PROGRAM OBJECTIVES

The specific objectives of the program were to:

- Simulate the dynamic response of a CH-47A helicopter to crash impact by exercising computer program KRASH.
- Correlate the predictions with data from a CH-47A crash test.
- Incorporate certain previously defined improvements to KRASH and recommend additional improvements to enhance the usefulness of the program.

In order to meet the objectives in a timely manner, the following tasks were defined.

Task I

- Model the dynamic structural response of the CH-47A aircraft to crash impact forces using computer program KRASH. The model should represent the CH-47A aircraft to be crash tested in 1976 by ATL and NASA at NASA/Langley Research Center.
- Predict the structural response of the CH-47A to the following conditions representing a 95th-percentile survivable crash impact. These predictions were to be used in formulating detailed test plans for the projected CH-47A crash test.
    - Impact velocities

50 fps	Resultant
42 fps	Vertical
27.1 fps	Forward
0 fps	Lateral

    - Aircraft attitude

0 Degrees yaw
0 Degrees roll
5 Degrees nose-down pitch

    - Participate in the formulation of the test plan for and support the CH-47A crash test at NASA/LRC.

Task II

- Following the crash tests, exercise the CH-47A structural model on the KRASH computer program using actual test conditions, and correlate the results of the simulation with the crash test data. Improve the model accuracy to obtain better correlation between results of simulation and test data.

- Recommend improvements (and install modifications identified in Reference 4) to the KRASH computer program.

- Evaluate the crash impact performance of the fuselage.

Initially, the analytical efforts were to have utilized the Army-supplied KRASH III program. However, as Boeing Vertol had already incorporated several improvements into the KRASH code, it was decided that the improved KRASH code S-79 by Boeing Vertol would be used for all simulation studies.

The long-term goal of this and related crash simulation R&D programs is to validate KRASH as an analytical tool which would permit a quick and accurate evaluation of the crashworthiness of an aircraft sufficiently early in the design process to permit incorporation of required changes. In order to achieve this goal it is first necessary to determine the applicability and limitations of the KRASH program as it currently exists. During the performance of the tasks defined above a great deal of experience has been gathered in the use of the KRASH program and some of the limitations identified. Several of the limitations so identified have been eliminated through the improvements installed into the computer program and many other improvements are being made by the Lockheed-California Company under the terms of FAA Contract DOT-FA75-WA-3707.

3.0 PRETEST SIMULATION STUDIES

3.1 KRASH COMPUTER PROGRAM

The KRASH computer program was developed during the 1972-1974 time period. The program computes the dynamic response of arbitrarily interconnected lumped masses to a defined set of initial impact conditions. Each of the masses has six degrees of freedom; the interconnection between masses is accomplished by beam-type elements. Loads are induced into the structure through the deformation of external springs extending from appropriate masses on the vehicle exterior. The equations of motion for each mass consider gravitational, aerodynamic, and inertial forces together with the internal forces and moments due to deformation of associated structural elements. Structural damping is also included. Nonlinear structural properties of a beam element are obtained by modifying the beam stiffness matrix by suitable stiffness reduction factors specified as piecewise linear functions of element deformation. A step-by-step numerical analysis scheme is used to integrate the resulting equations of motion. A detailed description of the development of the mathematical model, together with program listings, is found in Reference 1. A revised version of the program including some additions and improvements, as described in Reference 2, is now available as KRASH III.

The improved version KRASH III still possessed certain definite limitations. Specifically, the structural representation did not provide for pure pin-ended axially loaded elements. This prevented modeling of items such as airframe skins which carry load in diagonal tension. In addition, the program did not permit for variation in the size of the iteration time step based on a test of solution stability. Only a constant time step routine was provided. This could lead to rapid divergence and instability in the solutions to the equations of motion unless extremely small time steps were employed, which in turn would result in excessive computer run time and correspondingly high costs. Another identified limitation of KRASH III was that the algorithm used for computing beam axial load did not account for large deflections.

During work performed at Boeing Vertol in applying KRASH under other contracts with UMTA (Urban Mass Transportation Authority, Reference 15) and ATL, another version of KRASH was developed which incorporated a capability of handling the above problems. This program, designated S-79, was operational on the IBM 370-65 system and the Xerox Sigma 9 engineering computing system available through the Boeing Computer Services. At this time S-79 was only operational in single precision. Due to the core limitations of Sigma 9, the number of masses and interconnecting elements in an S-79 structural model were restricted.

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15. **Widmeyer, E., Tanner, A.E., and Klump, Robert, CRASHWORTHINESS ANALYSIS OF THE UMTA STATE-OF-THE-ART CARS, DOT-TSC-791-3, U.S. Department of Transportation, Urban Mass Transit Administration, Washington, D.C., June 1975.**

3.2 S-79 COMPUTER PROGRAM

As previously stated S-79 was essentially the KRASH III computer code with the following additional capabilities.

- Availability of a pin-ended axial structural element with tension only or compression only capability.
- Correction for the effects of large deflections on axial forces in the interconnecting elements.

In addition, during the course of this effort, the following previously identified improvements were installed on S-79.

- An optional integration scheme employing a variable time step based on input error controls.
- Improved solution stability with the incorporation of a ten-step integration scheme for element ruptures.
- Evaluation of hysteresis effects during element load-unload-load cycle.
- Restart capability which provides for the storing of the calculated time-dependent data. This permits modifying the initial parameters and continuing calculation at any stored time increment.

Detail discussions of these improvements together with appropriate program listings are given in Reference 3.

3.3 CH-47A KRASH MODEL

3.3.1 Preliminary Requirements

The primary requirements for the development of a KRASH model are the definition of mass points and associated mass values, interconnecting elements and their properties, and external springs which together will properly represent the structural dynamic properties of the aircraft in a crash environment.

In defining the mass distribution for the model, it is necessary to judiciously select locations that would represent the overall mass distribution of the airframe and also permit evaluation of the dynamic response of the airframe in regions of interest (i.e., near onboard experiments and crew seats). S-79 Program, Sigma 9 Version, limits the number of mass points to 80. However,

since on the average an addition of a mass point requires two or more beam elements, the possible number of mass points in the model is restricted by the limit on beam elements.

Interconnecting elements represent the overall axial, shear, bending, and torsional structural properties of the airframe. The number of elements is limited to 85 for the S-79, Sigma 9 version.

External springs are located at the underfloor and landing gear mass points. These springs are oriented vertically and represent the crushable underfloor structure and landing gears.

A baseline configuration of the CH-47A KRASH model was constructed in accordance with the foregoing requirements and is shown in Figure 2.

3.3.2 Model Mass Properties

Data for the mass properties was obtained from the following sources:

Test aircraft mass properties in terms of aircraft weight and c.g. location, together with the weights and locations of test equipment and experiments as supplied by ATL, are shown in Table 1 and Figure 3. Basic CH-47A helicopter mass property data is contained in the weight and balance report (Reference 16). In order to obtain an acceptable dynamic model, the model mass properties should closely correspond to those of the test article. For the purposes of this simulation, a match of the following as a minimum was required:

- Aircraft gross weight
- Aircraft longitudinal and vertical center-of-gravity position
- Moments of inertia about their own c.g. axes of large concentrated masses, e.g., powerplants
- Aircraft pitch moment of inertia

The nodal framework of the model is, to a large extent, dictated by the need to provide an adequate structural representation within the program constraints. Hence, the requirement to match both c.g. position and pitch moment of inertia leads to conflicting demands. Several iterations were, therefore, required before an acceptable nodal mass distribution was defined. This distribution and the model mass properties are shown in Table 2.

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16. WEIGHT, BALANCE, AND MOMENTS OF INERTIA OF THE YHC-1B HELICOPTER, Boeing document 114-W-03, Boeing Vertol Company, Philadelphia, Pennsylvania, 1961.

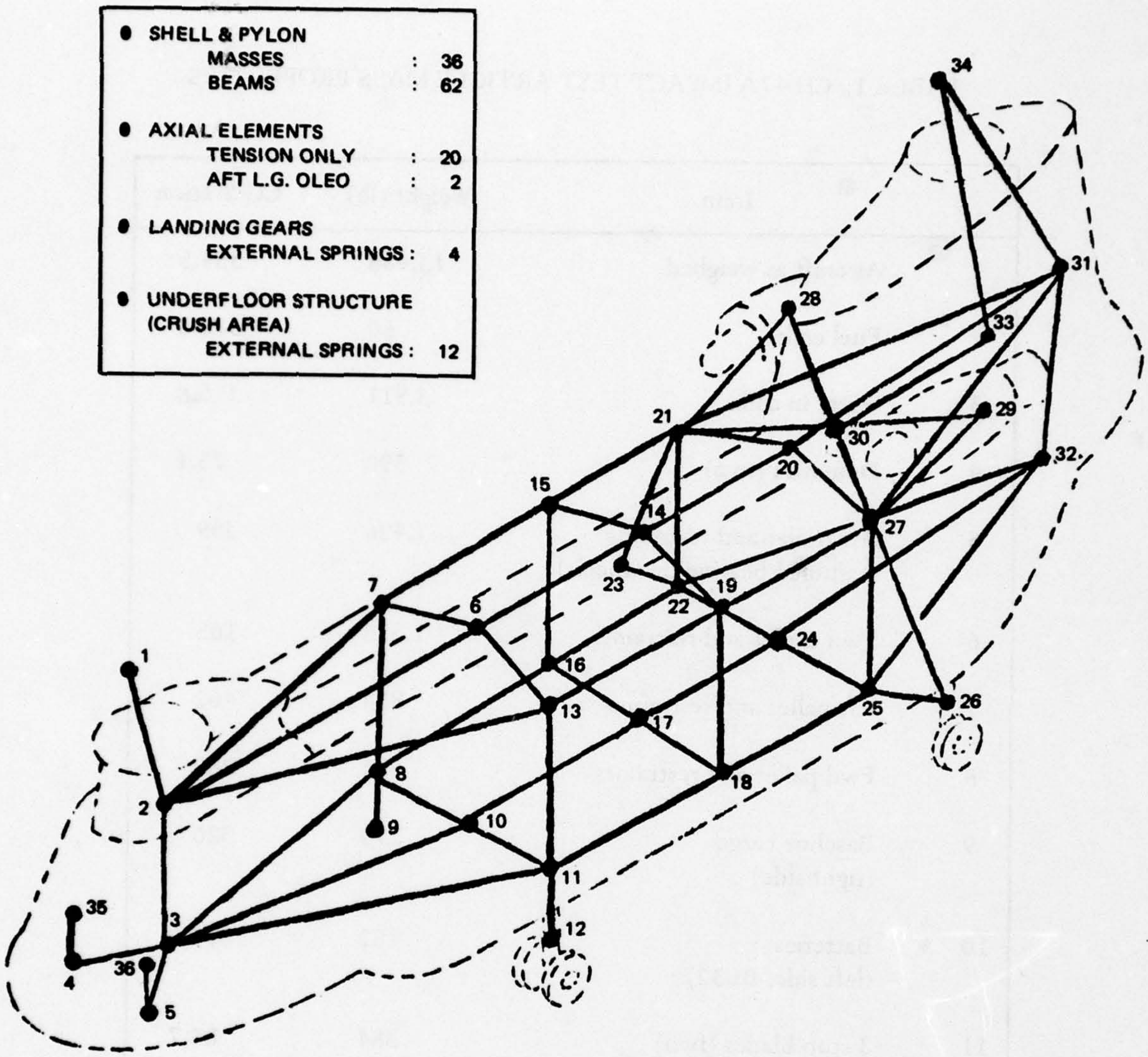

Figure 2. Pretest KRASH Mathematical Model of CH-47A Helicopter.

TABLE 1. CH-47A IMPACT TEST ARTICLE MASS PROPERTIES

	Item	Weight (lb)	CG Station
1	Aircraft as weighed	13,488	354.5
2	Fuel cells	60	316.8
3	Water in cells	3,811	316.8
4	Dummies (two)	390	75.1
5	Aft trailer and restraints (assumed bearing on wheels)	1,426	369
6	Fwd trailer and restraints	1,378	165
7	Aft pallet and restraints	834	462
8	Fwd pallet and restraints	814	280
9	Baseline cargo (right side)	179	326
10	Batteries (left side, BL32)	152	300
11	3 stub blades (fwd)	384	86.7
12	3 stub blades (aft)	384	553.7
13	Ballast	1,000	107.5
	Total	24,300	323.5

Estimated pitch inertia = 1.904×10^6 lb in. sec^2

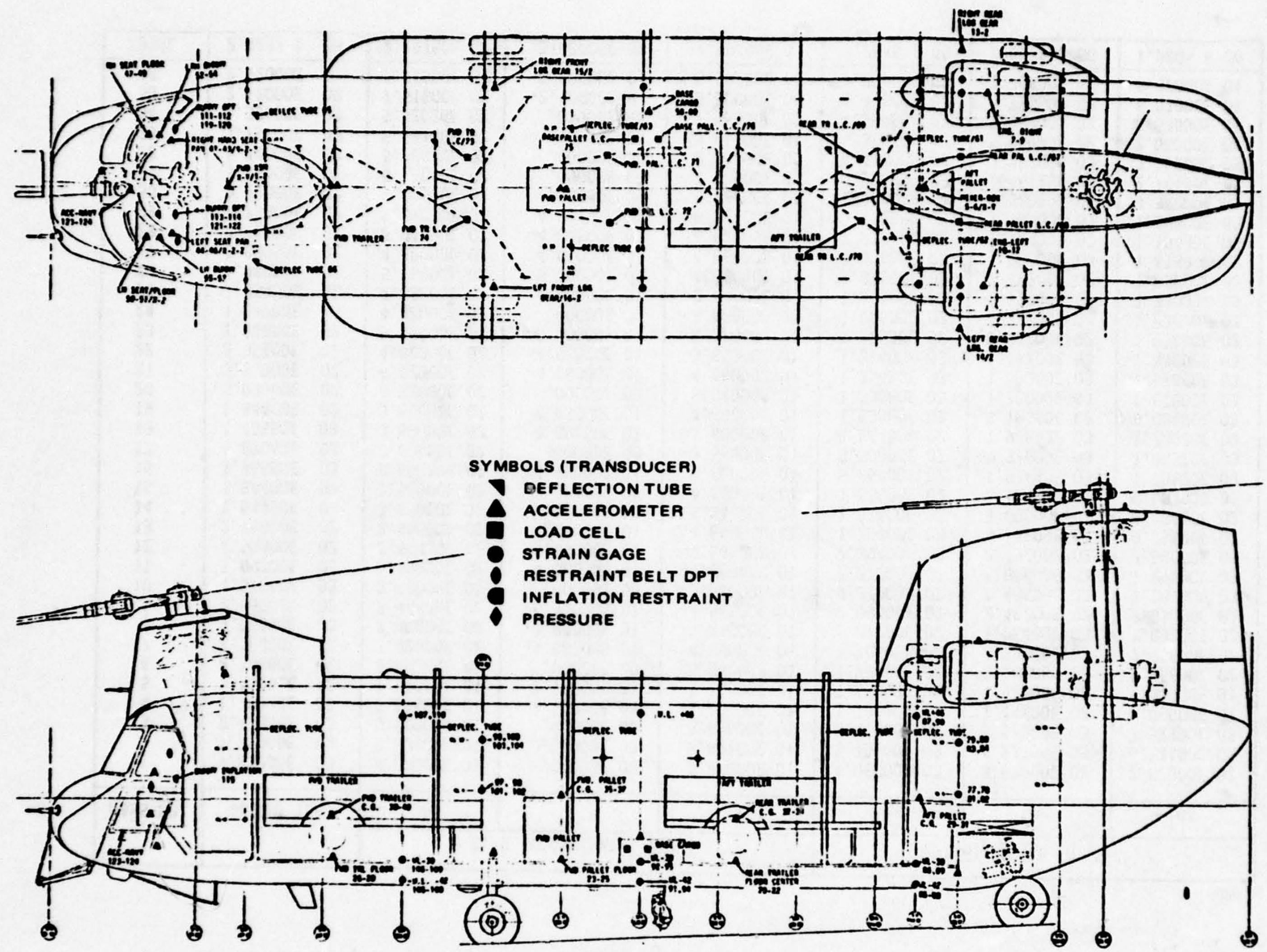

Figure 3. Details of Experiments and Instrumentation on CH-47A Impact Test Article.

TABLE 2. CH-47A CRASHWORTHINESS PRETEST MODEL MASS PROPERTIES

MASS NO.	WEIGHT (LB)	C. G. COORDINATES (IN.) X	Y	Z	INERTIAS (LB IN. SEC^2) I_{ox}	I_{oy}	I_{oz}
1	1.21200E 03	8.60000E 01	.00000E 00	9.98800E 01	4.08000E 02	3.97000E 02	7.62000E 02
2	1.71800E 03	9.23400E 01	.00000E 00	6.62700E 01	5.19500E 03	6.27100E 03	6.13400E 03
3	2.47800E 03	9.50000E 01	.00000E 00	-3.60000E 01	6.37900E 03	6.67900E 03	7.52900E 03
4	1.75000E 02	7.51500E 01	-2.10000E 01	-1.70000E 01	1.13000E 01	1.44800E 02	5.00000E 01
5	1.75000E 02	7.51500E 01	2.10000E 01	-1.70000E 01	1.13000E 01	1.44800E 02	5.00000E 01
6	2.18800E 02	2.40000E 02	.00000E 00	5.54000E 01	1.70400E 02	8.38800E 02	9.75600E 02
7	2.18800E 02	2.40000E 02	-4.65000E 01	4.66000E 01	1.70400E 02	8.38800E 02	9.75600E 02
8	1.06900E 03	2.40000E 02	-4.88000E 01	-3.60000E 01	1.27200E 02	1.86400E 03	1.89800E 03
9	2.58000E 02	2.44430E 02	-6.30000E 01	-4.56500E 01	2.39400E 02	2.49200E 02	3.56000E 01
10	1.57600E 03	2.40000E 02	.00000E 00	-3.60000E 01	4.37000E 02	1.43500E 03	1.58100E 03
11	1.09300E 03	2.40000E 02	4.88000E 01	-3.60000E 01	7.27200E 02	1.86400E 03	1.89800E 03
12	2.58000E 02	2.44430E 02	6.30000E 01	-4.56500E 01	2.39400E 02	2.49200E 02	3.56000E 01
13	2.18800E 02	2.40000E 02	4.65000E 01	4.66000E 01	1.70400E 02	8.38800E 02	9.75600E 02
14	1.54400E 02	3.60000E 02	.00000E 00	5.54000E 01	1.53600E 02	5.19600E 02	6.08400E 02
15	1.54400E 02	3.60000E 02	-4.65000E 01	4.66000E 01	1.53600E 02	5.19600E 02	6.08400E 02
16	1.45860E 03	3.60000E 02	-4.88000E 01	-3.60000E 01	6.26400E 02	1.97640E 03	1.70520E 03
17	1.82060E 03	3.60000E 02	.00000E 00	-3.60000E 01	8.80800E 02	1.92600E 03	1.96320E 03
18	1.40660E 03	3.60000E 02	4.88000E 01	-3.60000E 01	6.26400E 02	1.97640E 03	1.70520E 03
19	1.54400E 02	3.60000E 02	4.65000E 01	4.66000E 01	1.53600E 02	5.19600E 02	6.08400E 02
20	3.03900E 02	4.82000E 02	.00000E 00	5.54000E 01	1.33680E 03	1.38000E 03	1.61880E 03
21	3.03900E 02	4.82000E 02	-4.65000E 01	4.66000E 01	1.33680E 03	1.38000E 03	1.61880E 03
22	2.35400E 02	4.82000E 02	-4.88000E 01	-3.60000E 01	1.36600E 03	1.17700E 03	1.33000E 03
23	1.96000E 02	5.15000E 02	-6.70000E 01	-4.08000E 01	1.37600E 02	2.77200E 02	1.83600E 02
24	1.03740E 03	4.82000E 02	.00000E 00	-3.60000E 01	1.36600E 03	1.17700E 03	1.33000E 03
25	2.35400E 02	4.82000E 02	4.88000E 01	-3.60000E 01	1.36600E 03	1.17700E 03	1.33000E 03
26	1.96000E 02	5.15000E 02	6.70000E 01	-4.08000E 01	1.37600E 02	2.77200E 02	1.83600E 02
27	3.03900E 02	4.82000E 02	4.65000E 01	4.66000E 01	1.33680E 03	1.38000E 03	1.61880E 03
28	7.73000E 02	5.04920E 02	-4.84500E 01	6.62400E 01	1.21200E 02	1.10400E 03	1.10400E 03
29	7.73000E 02	5.04920E 02	4.84500E 01	6.62400E 01	1.21200E 02	1.10400E 03	1.10400E 03
30	3.22000E 02	4.62620E 02	.00000E 00	5.65800E 01	3.00000E 01	4.32000E 01	4.32000E 01
31	3.15000E 02	5.76000E 02	.00000E 00	1.00000E 02	2.93520E 03	2.16120E 03	2.16120E 03
32	4.74000E 02	5.76000E 02	.00000E 00	8.50000E 00	4.41600E 03	3.25200E 03	3.25200E 03
33	1.19200E 03	5.58100E 02	.00000E 00	5.95000E 01	1.38960E 03	5.96400E 02	2.05200E 02
34	1.39600E 03	5.52620E 02	.00000E 00	1.55530E 02	1.38960E 03	5.96400E 02	6.53000E 01
35	2.12000E 02	7.51500E 01	-2.10000E 01	5.50000E 00	1.37000E 02	1.75000E 02	6.07000E 01
36	2.12000E 02	7.51500E 01	2.10000E 01	5.50000E 00	1.37000E 02	1.75000E 02	6.07000E 01
TOTAL	2.4298 E 04	3.20180E 02	5.62000E-02	1.19260E 01	3.2646 E 05	2.0874 E 06	1.9205 E 06

3.3.3 Model Structural Properties

The basic structure of the CH-47A airframe excluding skin-type shear elements is shown in Figure 4. Constructional details of a typical fuselage frame element are shown in Figure 5. The properties of the structural elements in the math model were assembled, making use of several sources as follows:

Airframe structural analysis substantiating the ultimate strength of the airframe for design loading conditions given in References 17 through 20. These documents contain detailed structural properties for all elements constituting primary load paths within the basic structure, including their ultimate load capability. Further, the design static strength of the airframe was substantiated during the CH-47A Static Test Program conducted by the U.S. Air Force at Wright-Patterson Air Force Base. The results of the test program are available in Reference 21. Although Reference 21 does not include any details of structural failures evidenced during the several static tests, such data are contained in some unpublished notes available at Boeing Vertol.

The above data were utilized to obtain preliminary structural properties for the interconnecting "beam" elements. Based on extensive data from shear beam tests conducted by NASA, Reference 22, the diagonal tension field strength of the skin panels was approximated to define suitable "tie rod" areas. Factors representing the lumping together of several frame bays to form the KRASH model frame/longitudinal bending elements and the effects of high rates of strain on elastic properties were utilized to obtain the model element properties in the elastic range. Stiffness reduction factors were evaluated on the basis of known behavior in the plastic range of similar structural elements under dynamic loading conditions contained in References 2 and 23, and test data obtained during dynamic tests on riveted joints. Rupture criteria for key elements were developed utilizing high rates of strain data and estimated failure modes. The properties of the external springs representing the "crush" capabilities of the underfloor structure were

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17. FORWARD PYLON ANALYSIS, VERTOL MODEL YHC-1B, HC-1B, Boeing document 114-S-08.2.1, Boeing Vertol Company, Philadelphia, Pennsylvania, April 1961.

18. CENTER SECTION ANALYSIS, VERTOL MODEL YHC-1B, HC-1B, Boeing document 114-S-08.2.3, Part I, Boeing Vertol Company, Philadelphia, Pennsylvania, March 1961.

19. CENTER SECTION ANALYSIS, VERTOL MODEL YHC-1B, HC-1B, Boeing document 114-S-08.2.3, Part II, Boeing Vertol Company, Philadelphia, Pennsylvania, March 1961.

20. AFT PYLON ANALYSIS, VERTOL MODEL YHC-1B, HC-1B, Boeing document 114-S-08.2.2, Boeing Vertol Company, Philadelphia, Pennsylvania, March 1961.

21. Schneider, R.L., STATIC TEST PROGRAM FOR CH-47A HELICOPTER, USAFFDL RTD-TDR-63-4230, U.S. Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, 1963.

22. Kuhn, Peterson, and Levin, A SUMMARY OF DIAGONAL TENSION, PART II, EXPERIMENTAL EVIDENCE, NACA TN2662, National Advisory Committee for Aeronautics, Washington, D.C., May 1952.

23. SURVEY OF STRAIN RATE EFFECTS ON MECHANICAL PROPERTIES OF MATERIALS, Boeing document SA2-5522-1-449, The Boeing Company, Seattle, Washington, August 1968.

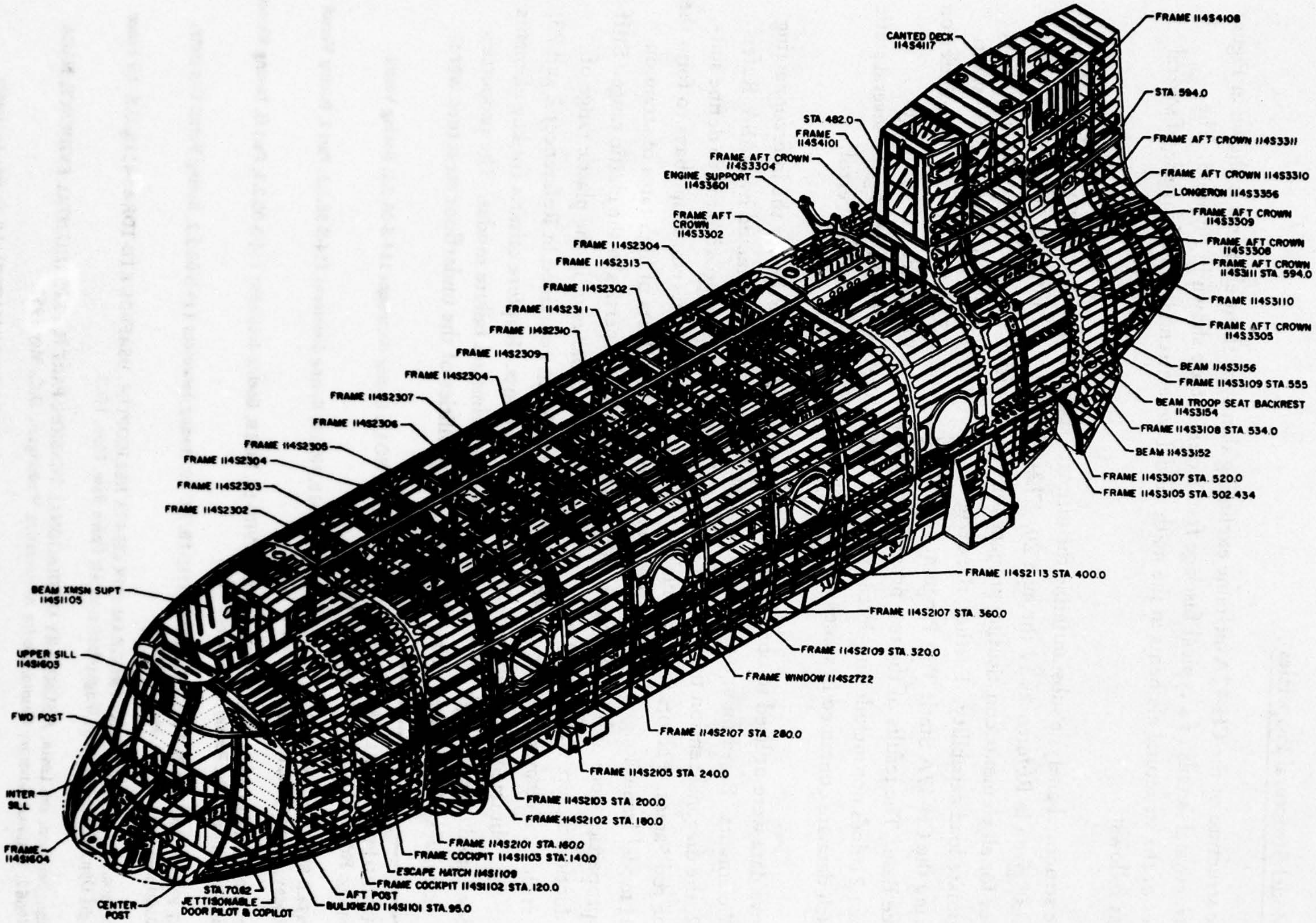

Figure 4. Basic Structure of the CH-47A.

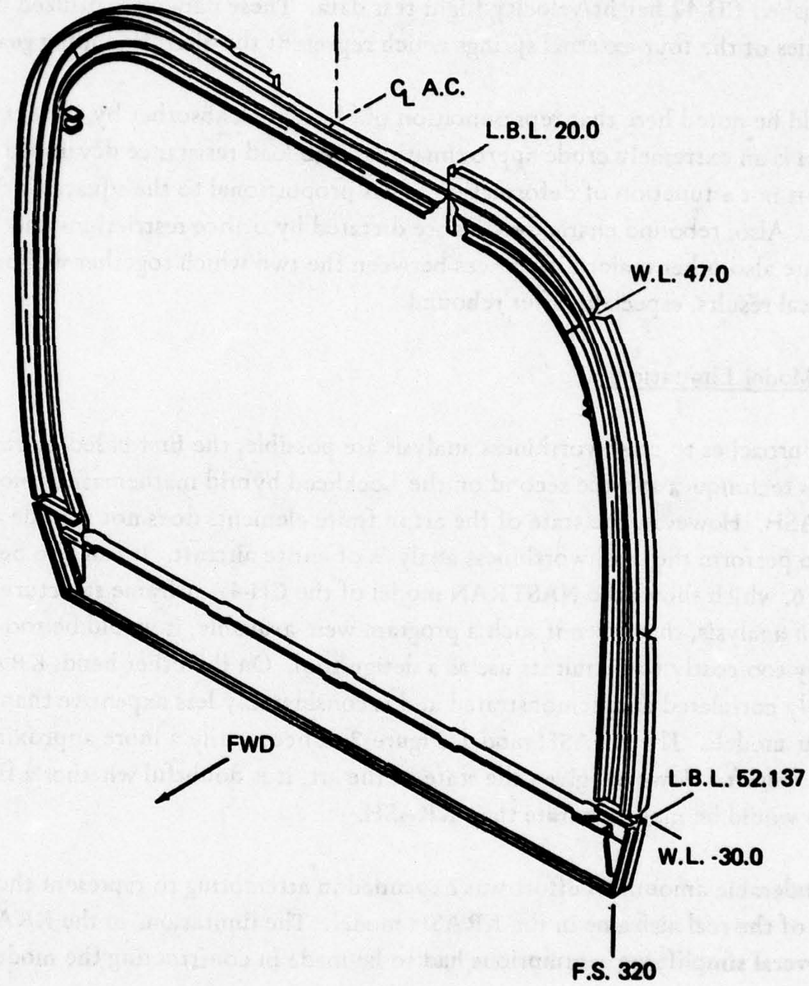

Figure 5. Typical CH-47A Center Section Fuselage Frame.

approximated from available structural data for these areas together with applicable test data. Sample calculations are shown in Appendix A.

The basic strength data for the main and auxiliary landing gears were obtained from References 24 and 25. Performance and failure modes data are available from References 26 and 27, and unpublished CH-47 height/velocity flight test data. These data were utilized in defining the properties of the four external springs which represent the aircraft landing gear.

It should be noted here that representation of oleo shock absorber by the external springs in KRASH is an extremely crude approximation. The load resistance developed by oleos during impact is not a function of deformation but is proportional to the square of the velocity of closure. Also, rebound characteristics are dictated by orifice restrictions and hence nonlinear. There are also other major differences between the two which together will produce inaccurate analytical results, especially after rebound.

3.3.4 Model Limitations

Two approaches to crashworthiness analysis are possible, the first based on finite element analysis techniques and the second on the Lockheed hybrid mathematical model incorporated in KRASH. However, the state of the art in finite elements does not include a validated program to perform the crashworthiness analysis of entire aircraft. It can also be seen from Figure 6, which shows the NASTRAN model of the CH-47 airframe structure used for static strength analysis, that, even if such a program were available, it would be too cumbersome and possibly too costly to permit its use as a design tool. On the other hand, KRASH has been extensively correlated and demonstrated and is considerably less expensive than classic finite element models. The KRASH model, Figure 2, is necessarily a more approximate representation of the aircraft. However, given the state of the art, it is doubtful whether a finite element approach would be more accurate than KRASH.

A considerable amount of effort was expended in attempting to represent the structural behavior of the real airframe in the KRASH model. The limitations in the KRASH code required that several simplifying assumptions had to be made in constructing the model. These

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24. FORWARD LANDING GEAR ANALYSIS, VERTOL MODEL YHC-1B, HC-1B, Boeing document 114-S-05.1, Boeing Vertol Company, Philadelphia, Pennsylvania, January 1961.

25. AFT LANDING GEAR ANALYSIS, VERTOL MODEL YHC-1B, HC-1B, Boeing document 114-S-05.2, Boeing Vertol Company, Philadelphia, Pennsylvania, April 1961.

26. DROP TEST ON CH-47A FORWARD LANDING GEAR, Boeing document 114-T-75, Boeing Vertol Company, Philadelphia, Pennsylvania, April 1961.

27. DROP TEST ON CH-47A AFT LANDING GEAR, Boeing document 114-T-76, Boeing Vertol Company, Philadelphia, Pennsylvania, May 1961.

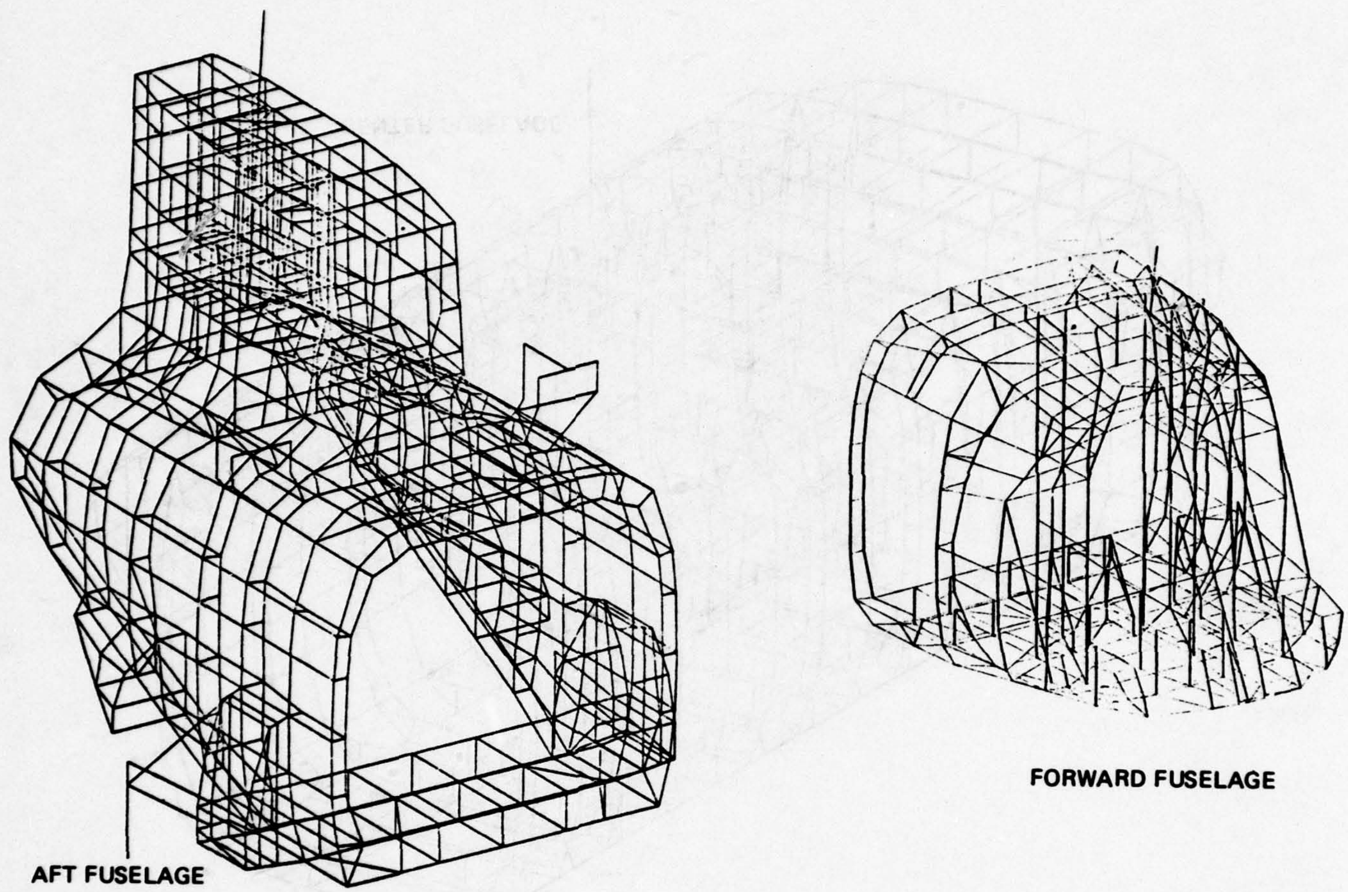

Figure 6. NASTRAN Model of the CH-47 Airframe Structure.

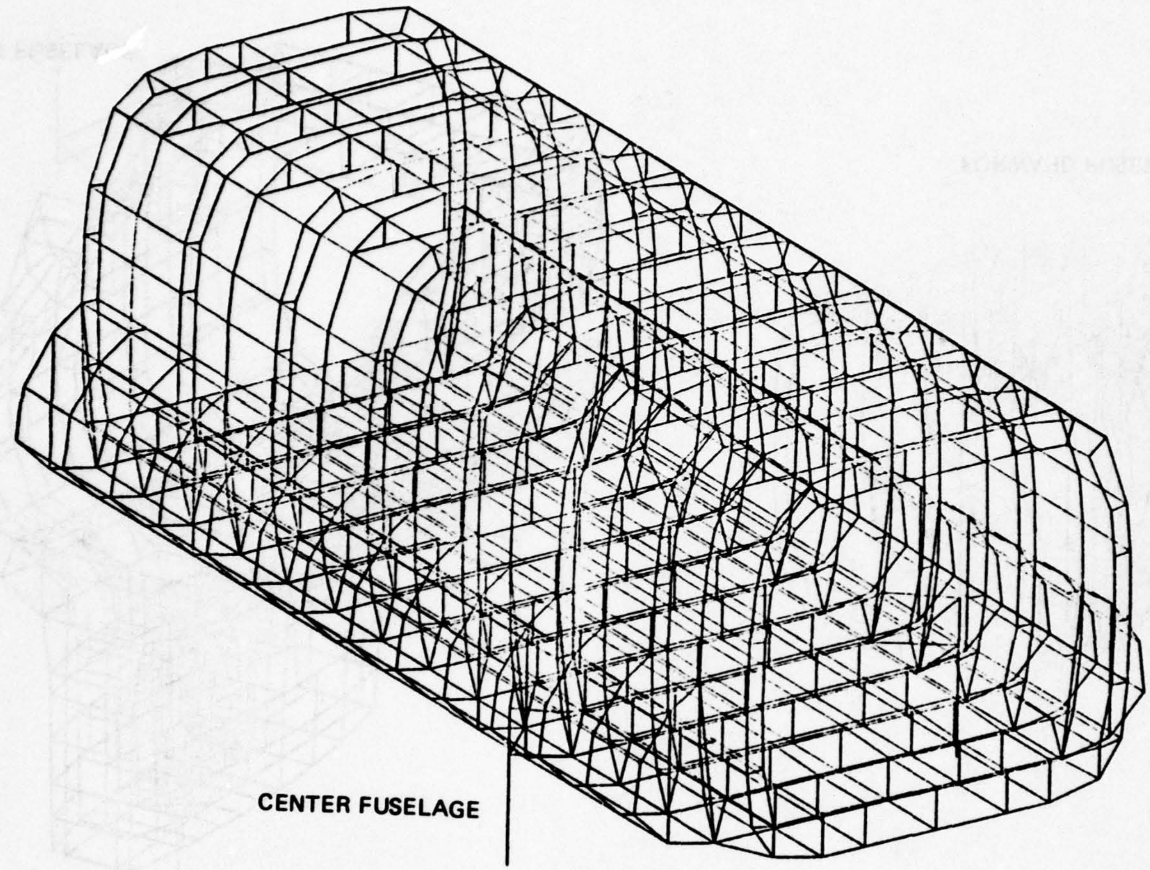

Figure 6. Continued

simplifications tend to mask detailed structural response and provide a poor resolution. It is therefore recognized that the dynamic response obtained by simulating this model for a given crash impact condition can only be used to predict the overall dynamics of the aircraft and gross structural behavior. Even here the accuracy of the model response past the initial power stroke is somewhat questionable due to the approximations involved in the modeling of the landing gear and frangible structure.

3.4 PRETEST PREDICTIONS

Several computer runs of the CH-47A crashworthiness model were made initially to debug and fine tune the model for the defined impact conditions. Some of the problems which surfaced during these initial runs are discussed here.

The first problem concerned stability of the solution process. A gross instability was indicated by the monotonic divergence of the total energy of the system as the solution progressed. For stable solutions, the total energy must remain a constant. A detailed analysis of the computer results showed that the energy divergence was due to negative strain energy feeding back into the system. The negative energy was being generated because of inconsistency between the coupled terms in the stiffness matrix of a given beam element, associated stiffness reduction factors and the method used in the KRASH program to compute beam internal forces and moments. Errors in this computation affect the forces and moments applied to the connected mass. A rapid divergence in the solutions to the equations of motion results.

An exact resolution to this problem requires the stiffness reduction (KR) factors to take into account the coupling constraints between translational and rotational deformations of a beam element at each computational step. This requirement can be met by modifying the DERIV subroutine in KRASH to include a logic block to check compatibility of and make suitable corrections to the KR tables defined initially. Modifications were beyond the scope of this effort, so an alternative procedure was adopted. This consisted of progressively adjusting, during the solution process, the interrelationship between coupled terms of the stiffness matrix and associated KR factors on the basis of beam deformation relationships, until an acceptable stable solution was obtained. The stability of the solution was considered acceptable provided that the following criteria were satisfied throughout the solution process:

- If negative strain energy is computed for a structural element, this strain energy should be less than one percent of the total strain energy in the model.

- The total energy of the model should be within ten percent of the value at impact.

It was also noticed that although the simulated impact conditions were symmetrical about the aircraft vertical plane there was a high degree of asymmetry in the model dynamic response

which could not be accounted for by the slight nonsymmetrical location of the aircraft lateral c.g. This problem is treated in greater detail in section 5.2.

Subsequent runs showed that the energy growth problem had been acceptably resolved. Several runs were then made with minor modifications to the model until a satisfactory simulation was established. Stable solutions were obtained over a solution time of 0.20 second after impact. The number of iterations required for the final pretest run was in excess of 4,000. Figure 7 is a time history of the predicted vehicle. It is seen that there is a 7.2-percent loss in total energies over the solution time.

In another similar study, Reference 28, it is reported that the total energy change was 2.5% over 0.160 second. The model sizes in the two studies are comparable but the latter involved only about half the number of iterations. It was, therefore, concluded that the stability of the solution process was satisfactory.

The results of this last simulation were used to predict the dynamic response of the CH-47A aircraft during the crash impact test. Figure 8 shows time histories of model c.g. horizontal and vertical velocities. It is seen that the vertical velocity is reduced by approximately 50% during the first 0.06 second after impact; further deceleration occurs at significantly reduced rates. From Figure 7, it can also be seen that a significant part of the vehicle kinetic energy has been absorbed through crushing and strain energy mechanisms by this time. The vehicle horizontal velocity, however, decreased at a fairly steady rate as, apart from frictional effects, there is no other specific energy absorption mechanism available for this component of the kinetic energy.

Table 3 is a summary of predicted significant events during the crash impact sequence showing the time after impacts at which individual structural elements in the model rupture and when ground contact at specific mass points occur together with the associated vehicle c.g. velocities. The data indicate that by 0.065 second after impact, the floor frame lower longerons and shell elements at fuselage station 240 have experienced structural failure. The progressive loss of model structural connectivity is illustrated in Figure 9. The time histories of predicted crushing of the underfloor structure (represented in the model by external springs) are shown for three nodal locations in Figures 10 through 12.

Longitudinal and vertical accelerations for all masses to the left of the model plane of symmetry obtained from this pretest simulation were subsequently processed by ATL using a 100-Hz, low-pass (LP) digital filter described in Reference 14. The processed data is included in Appendix B.

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28. Wittlin, Gil, and Gamon, Max A., A METHOD OF ANALYSIS FOR GENERAL AVIATION AIRPLANE STRUCTURAL CRASHWORTHINESS, FAA-RD-76-123, U.S. Department of Transportation, Federal Aviation Administration, Systems Research and Development Service, Washington, D.C., September 1976.

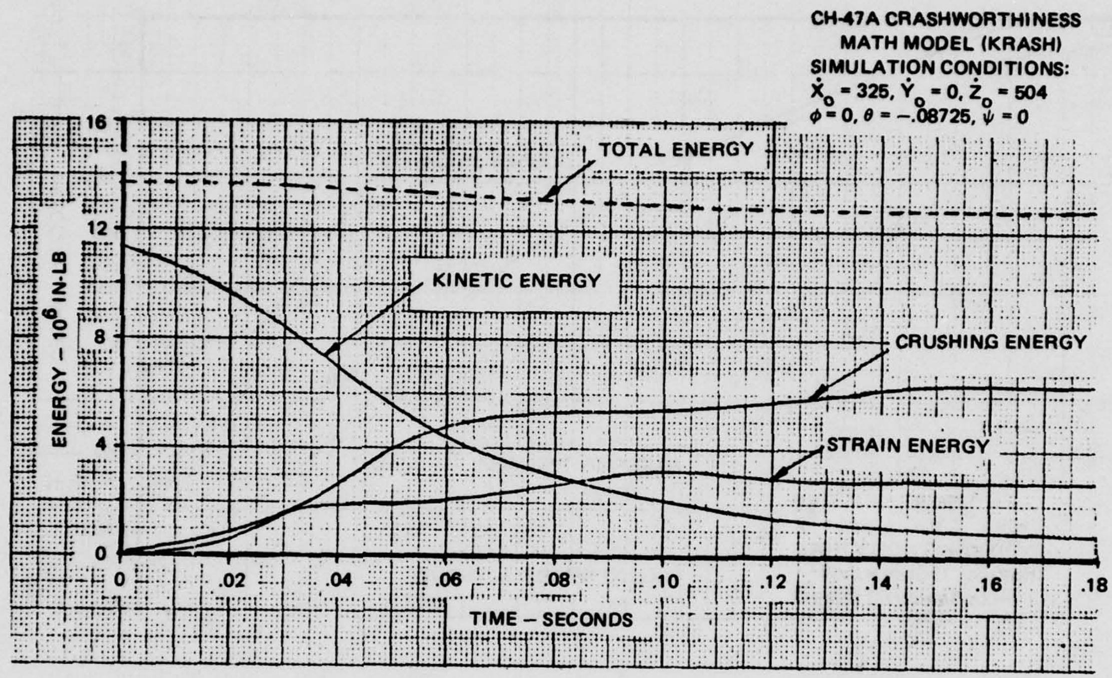


Figure 7. Predicted Energy Absorption Mechanisms – Pretest.

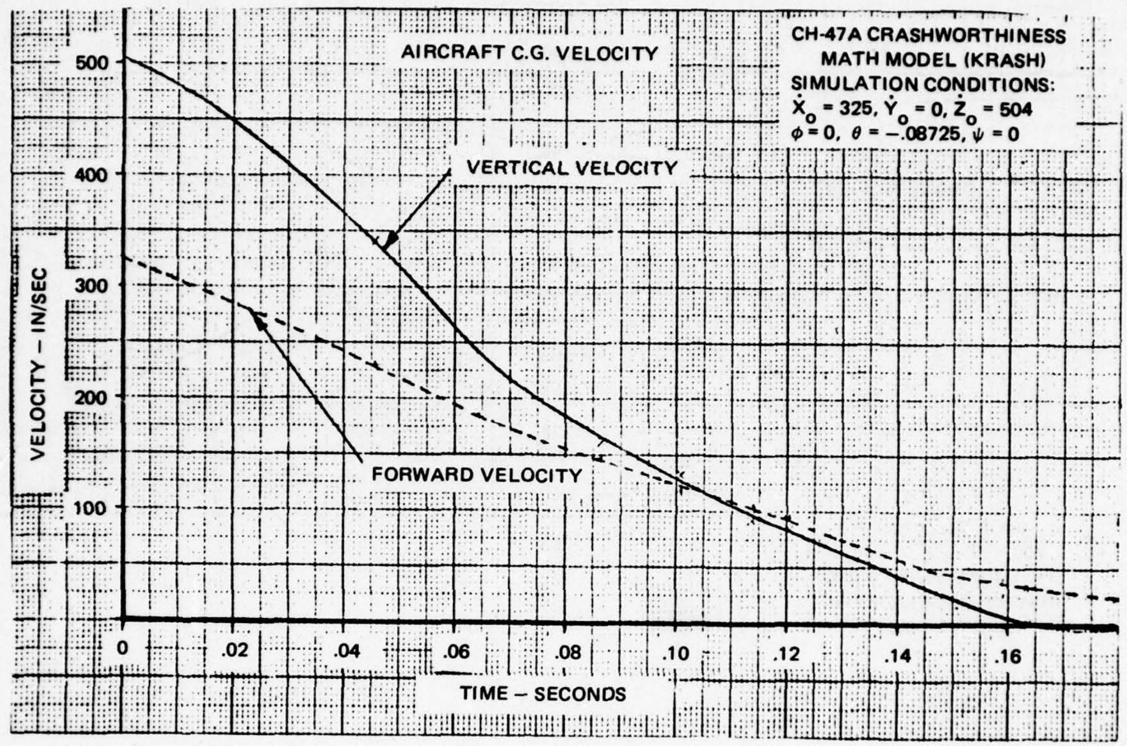


Figure 8. Predicted C. G. Velocities – Pretest.

TABLE 3. PREDICTED SEQUENCE OF EVENTS AFTER IMPACT (PRETEST)

Time	Element Rupture	Mass Point Contact	$\dot{X}$	$\dot{Z}$
0		9, 12	325	504
0.0302	10 – 11			
0.0411	17 – 18		230	340
0.0510*	16 – 17		215	318
0.0606		5		
0.0616	11 – 18			
0.0639	6 – 7			
0.0642		4	185	240
0.0651	8 – 16			
0.0687		3	169	218
0.0758	8 – 10		158	197
0.0907	6 – 13		132	144
0.1080		23	106	120
0.1136**		26	104	92
0.1171	13 – 19		1	
0.1271		17		
0.1373	14 – 19		53	56
0.1420	14 – 15		53	42
0.1570	7 – 15		32	0.9

* Center section skin aft of sta 320 buckled/rupture

** Center section bottom skin buckled/rupture

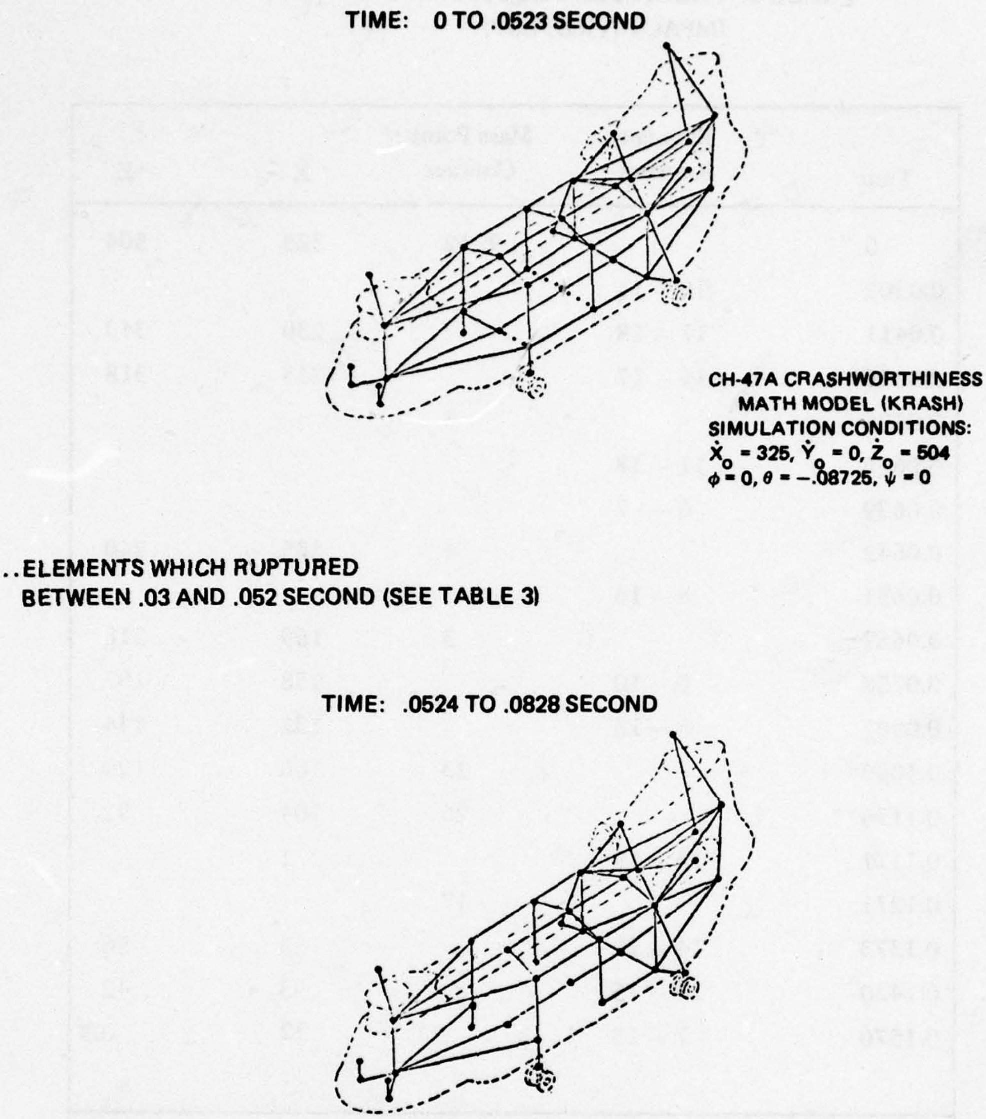
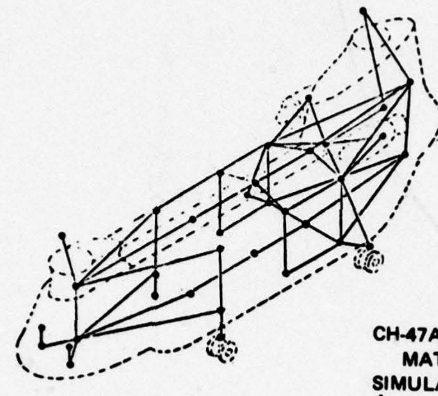


Figure 9. CH-47A Crashworthiness Predictions of Progressive Model States.

TIME: .0829 TO .1178 SECOND



CH-47A CRASHWORTHINESS
MATH MODEL (KRASH)
SIMULATION CONDITIONS:
$\dot{X}_o = 325, \dot{Y}_o = 0, \dot{Z}_o = 504$
$\phi = 0, \theta = -.08725, \psi = 0$

TIME: .1179 TO .2029 SECOND

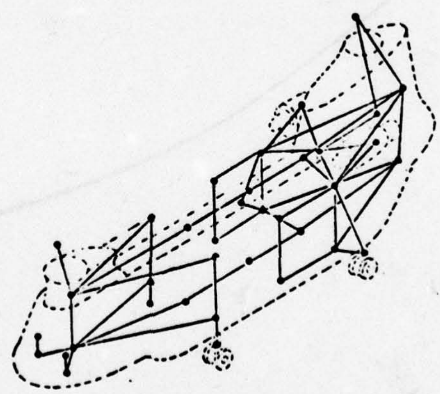


Figure 9. Continued

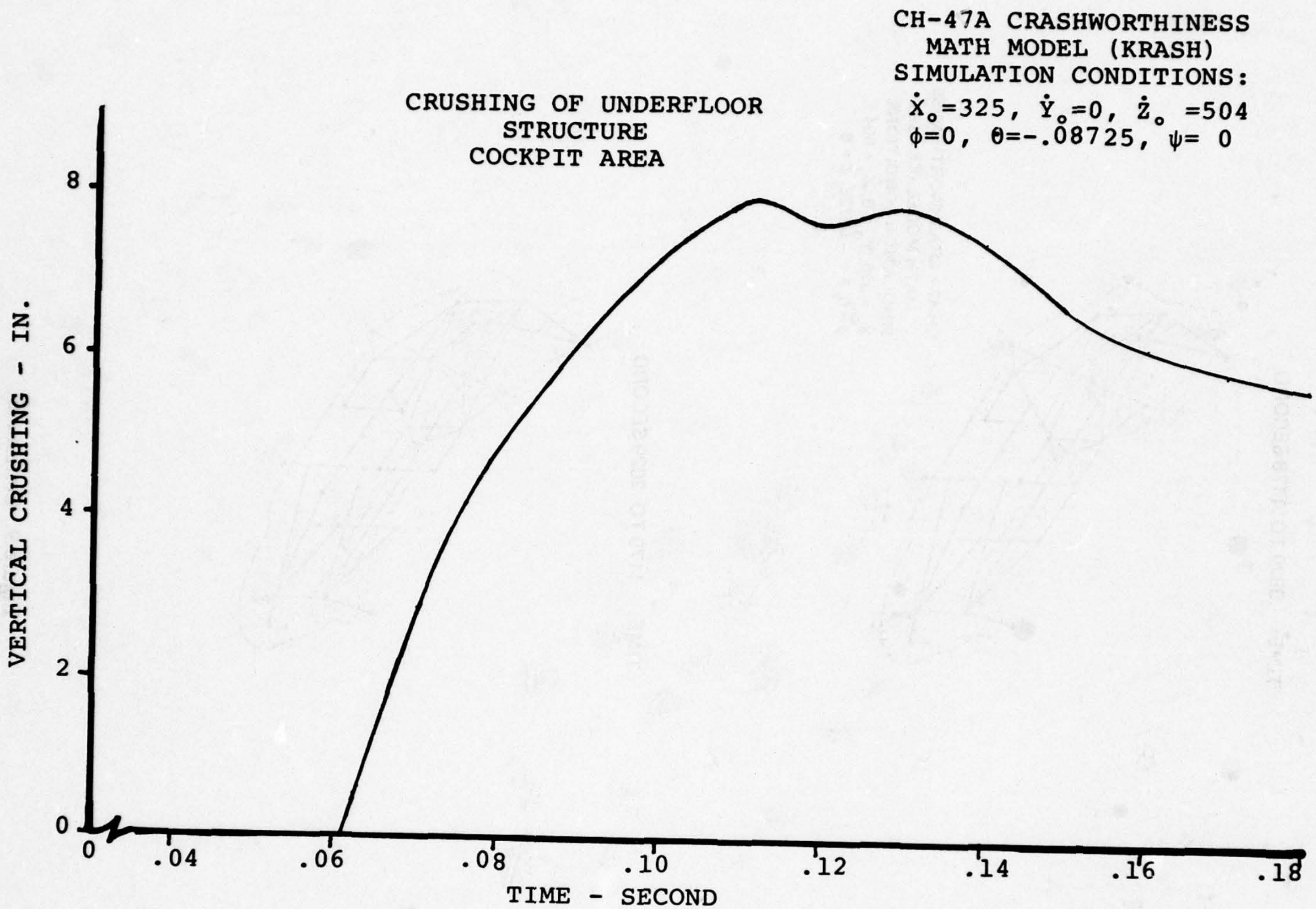


Figure 10. Predicted Crushing of Cockpit Area.

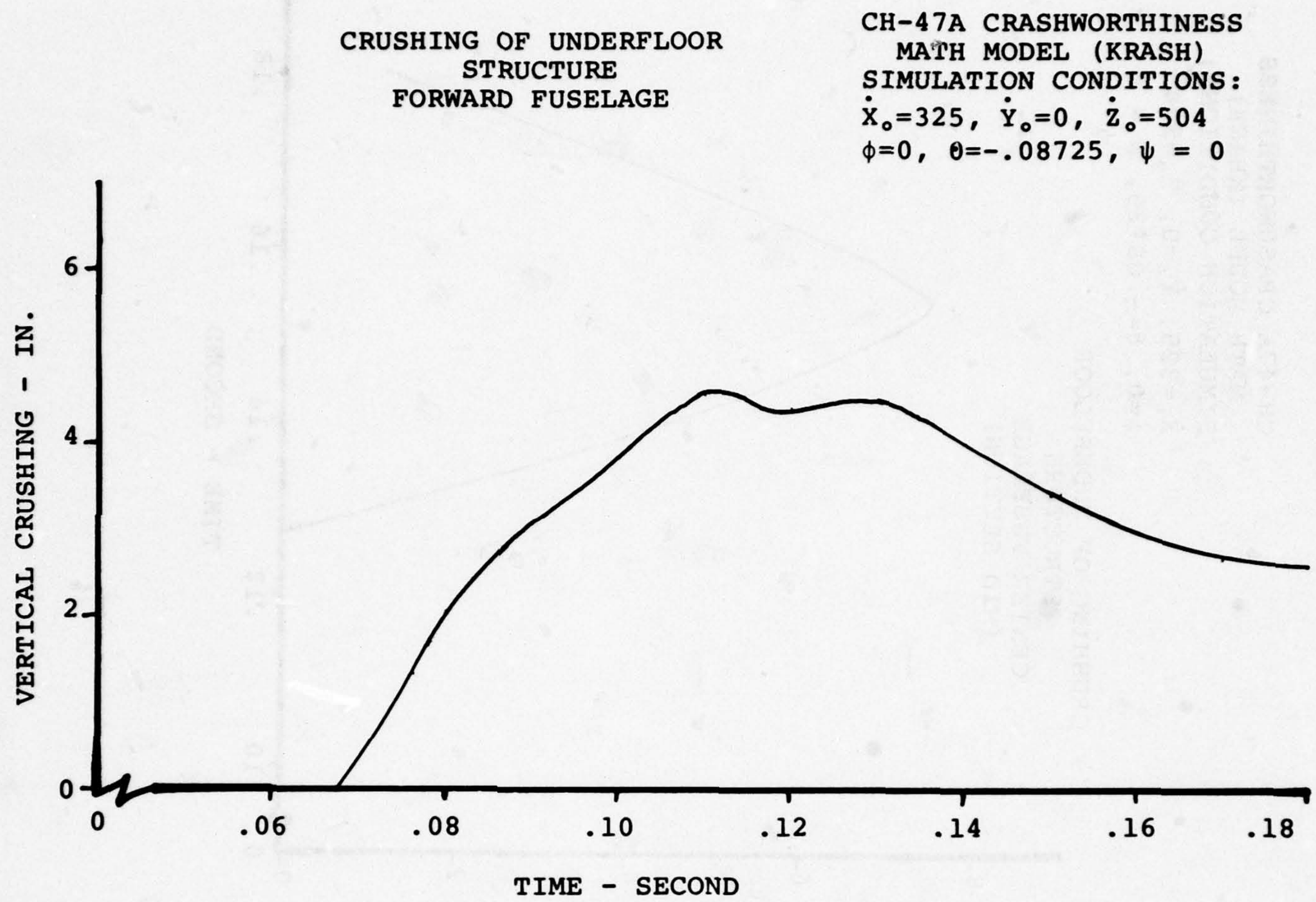


Figure 11. Predicted Crushing of Forward Fuselage.

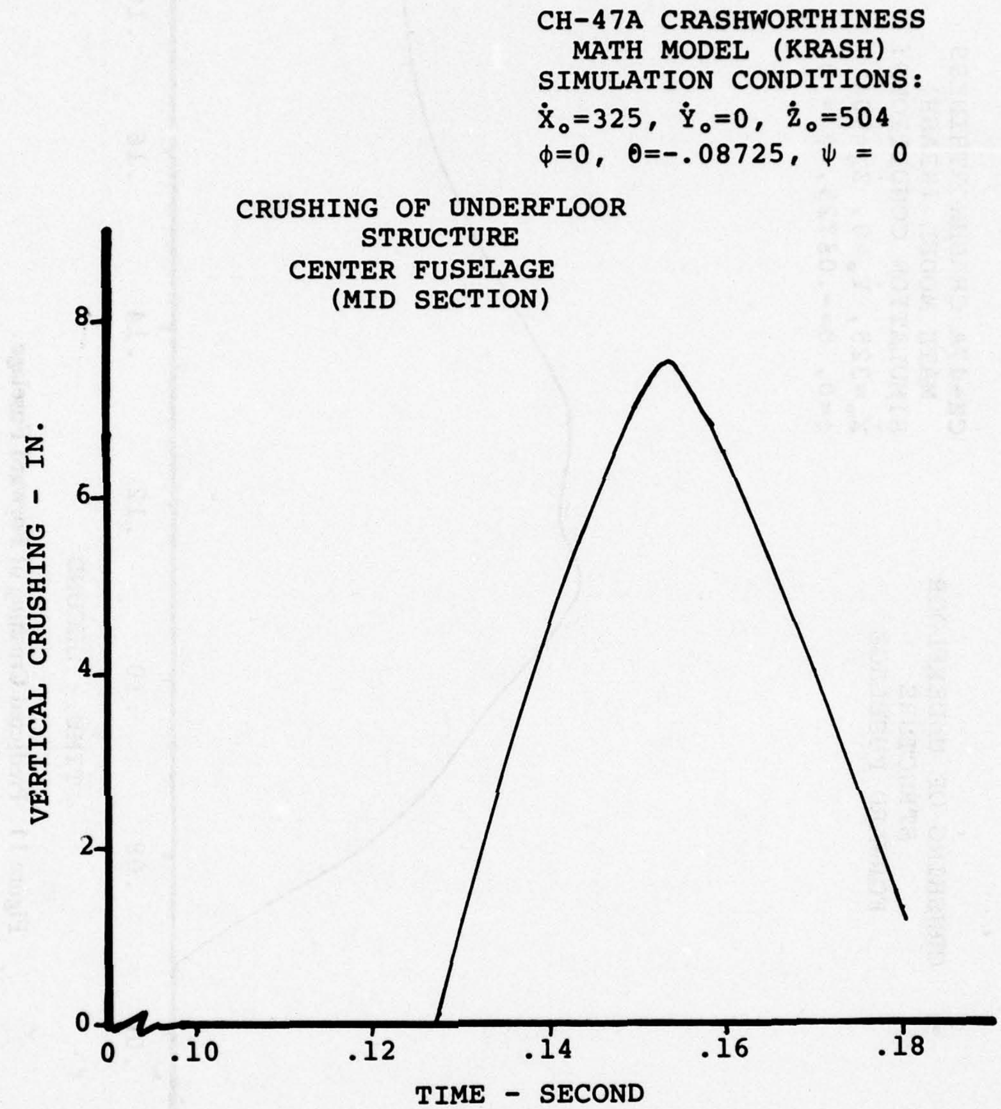


Figure 12. Predicted Crushing of Center Section.

4.0 CH-47A CRASH IMPACT TEST

4.1 OBJECTIVES

The principal objectives of the test were:

a. To obtain data on the dynamic response of the helicopter when subjected to a 95th-percentile survivable crash impact. The test data will be correlated with the predicted dynamic response of the CH-47A KRASH model for the prescribed impact conditions. These correlation studies are intended to help develop the KRASH program into a useful simulation tool for the crashworthiness analysis of an aircraft during its design stage.

b. To obtain data and evaluate energy-absorbing cargo restraint systems as compared to conventional cargo restraint systems in attenuating crash-induced forces on the cargo in order to optimize cargo restraint and tiedown point structural design criteria.

c. To evaluate the performance of an NADC-developed inflatable crashworthy crew restraint system under a 95th-percentile survivable helicopter crash impact loading condition.

d. To obtain additional data on structural dynamics of a helicopter airframe under crash impact loadings which will contribute to the development of crashworthiness features in future helicopters.

Objective (a) is the focus of the efforts described in this report.

4.2 TEST ARTICLE DESCRIPTION

The test article was an early model CH-47A helicopter, U.S. Army Serial No. 61-2418, B/V Tab No. B22, manufactured by Boeing Vertol in 1963. The aircraft life-cycle maintenance and ownership record for the helicopter shows that this helicopter was retired from active status in late 1967. A preliminary visual inspection of the aircraft indicated that the primary structural areas of its airframe were in good shape. The aircraft was equipped with engines, transmissions, stub rotor blades, and a noncrashworthy fuel system.

The test article included the following (see Reference 29 for a detailed description):

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29. Burrows, L. T., Lane, Richard, and McElhenney, James, CH-47 CRASH TEST (T-40) STRUCTURAL, CARGO RESTRAINT, AND AIRCREW INFLATABLE RESTRAINT EXPERIMENT, USARTL Technical Report TR78-22, Applied Technology Laboratory, U.S. Army Research and Development Laboratories (AVRADCOM), Fort Eustis, Virginia, 1978, AD A055804.

a. Cargo experiments in the center section fuselage area consisting of two 1/4-ton trailers, two pallet loads, and a baseline cargo. A conventional restraint system was employed for one trailer and one pallet. The restraint systems for the other pair employed improved restraints utilizing load-limiting energy absorbers.

b. NADC crew restraint experiments in the cockpit, with each seat occupied by an anthropomorphic dummy representing a 95th-percentile naval aviator.

c. Fuel cells were filled with water to obtain data on failure modes of fuel cells and fuel spray pattern during crash impact.

d. Sufficient ballast to obtain desired CG location for aircraft.

e. The data acquisition system included 125 channels as follows:

- 62 accelerometers
- 34 strain gages
- 8 tensiometers
- 10 load cells
- 8 deflection tubes
- 3 pressure transducers

f. Movie coverage of the internal experiments was provided by two movie cameras in the cockpit and seven in the cargo compartment.

In addition, motion picture coverage of the test was provided by 16 movie cameras located strategically around the test impact area.

Table 1 shows the estimated weight and CG positions of the on-board experiments. The locations of the individual experiments in the aircraft are shown in Figure 3. The fully configured test article gross weight was 25,010 pounds with its nominal center of gravity at fuselage Station 323.7. The pitch moment of inertia of the test article was estimated to be about 1.9×10^6 lb in. sec^2.

4.3 CRASH IMPACT TEST

The fully instrumented CH-47A helicopter was crash impact tested under the direction of the Applied Technology Laboratory (AVRADCOM) and NASA/Langley Research Center on August 4, 1976. The test was carried out at the Impact Dynamics Research Facility NASA/LRC. The test number was T-40. A detailed description of the test facility is given in Reference 30.

30. Vaughn, Victor L., Jr.,and Alfaro-Bou, Emilio, IMPACT DYNAMICS RESEARCH FACILITY FOR FULL-SCALE AIRCRAFT CRASH TESTING, NASA TND8179, National Aeronautics and Space Administration, Langley Research Center, Hampton, Virginia, April 1976.

The target impact conditions representing the 95th-percentile potentially survivable helicopter crash pulse were:

Impact Velocity

Resultant	–	50 ft/sec
Vertical	–	42 ft/sec
Forward	–	27.1 ft/sec
Lateral	–	0 ft/sec

Aircraft Attitude

Pitch	–	5° nose down
Yaw	–	0°
Roll	–	0°

Figure 13 shows the NASA/LRC impact test facility with the test article suspended prior to release. Pyrotechnic devices were used to initially sever the drawback cable attachments to the helicopter, permitting it to swing down, pendulum fashion, to impact the ground at the desired contact velocities and attitude. The swing cable attachments were severed on ground contact, permitting unrestrained motion of the helicopter subsequent to impact.

A series of still photographs taken at 0.05-second intervals during the crash sequence is shown in Figure 14. More detailed pictures of the external areas of the aircraft just before impact and at four later times are shown in Figures 15 through 19.

4.4 OBSERVATIONS AND RESULTS

Most of the observations made during and following the crash test confirmed predictions with respect to gross aircraft behavior.

Both left and right side fuel cells burst catastrophically as soon as ground contact of the fuel pod area occurred, resulting in 'fuel' spray enveloping the helicopter. The spray pattern can be seen initiating in Figure 17. It becomes quickly established. In an actual helicopter crash, although the incident may be classified "survivable" in terms of impact velocities and induced 'g' levels, this fuel spray would have ignited by any of several sources, e.g., hot engine parts, electronic equipment, and sparks from metal shavings. Even if the basic aircraft structure were able to attenuate the crash pulses to within human tolerance levels and prevent serious mechanical injury to the occupants, the ensuing fire would have resulted in the survivors sustaining extensive thermal injuries/fatalities. This test graphically demonstrates the pressing need for crashworthy fuel systems in aircraft to eliminate the threat from postcrash fire hazards.

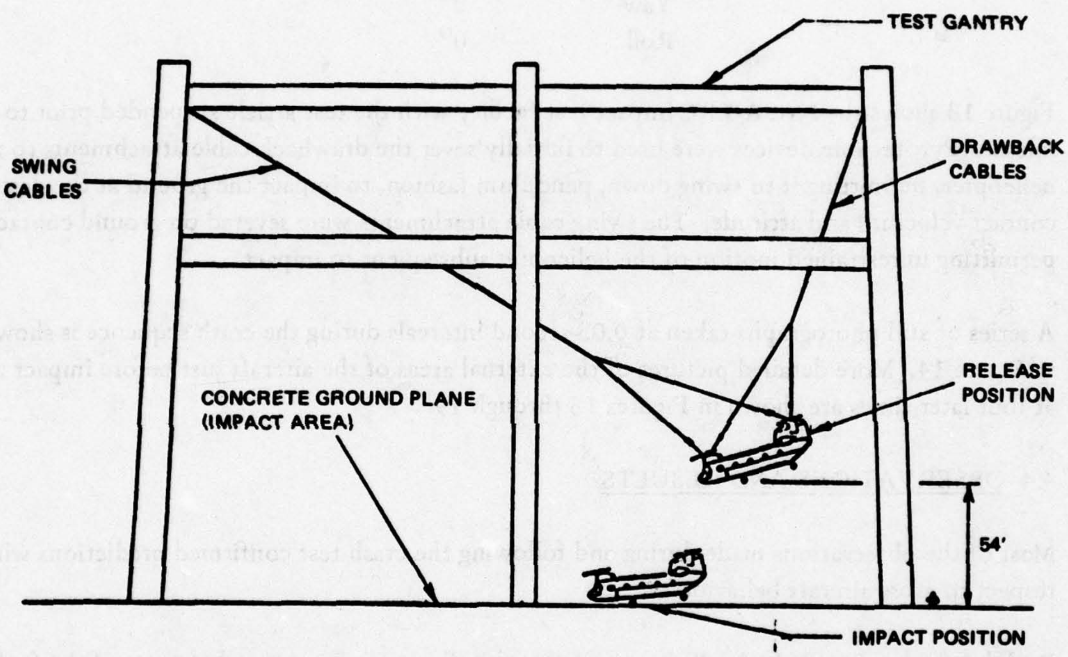

Figure 13. NASA/LRC Test Facility Showing CH-47A Test Setup.

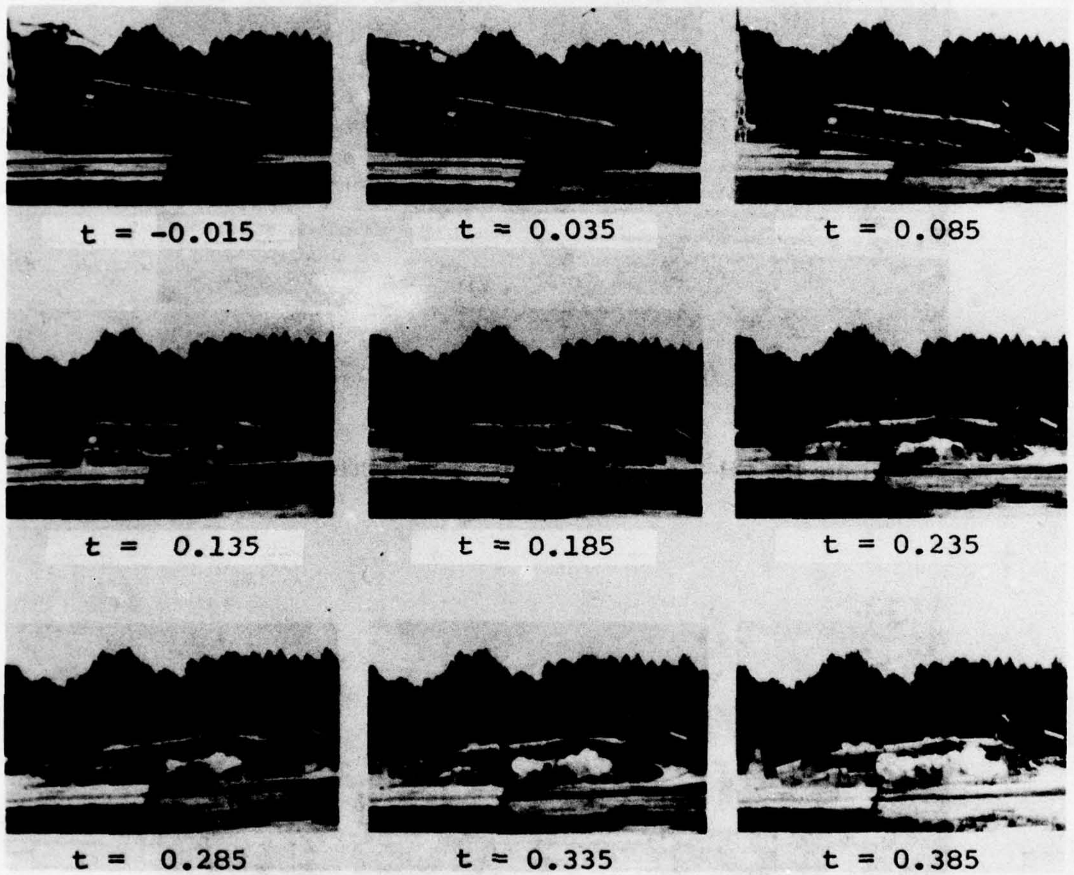

Figure 14. CH-47A Crash Test Sequence.

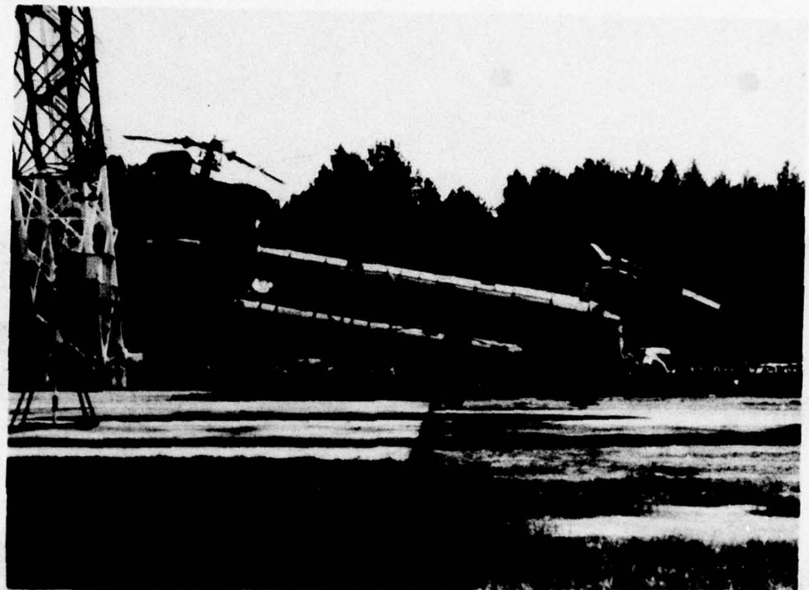

Figure 15. CH-47A Crash Test .015 Second Before Impact.

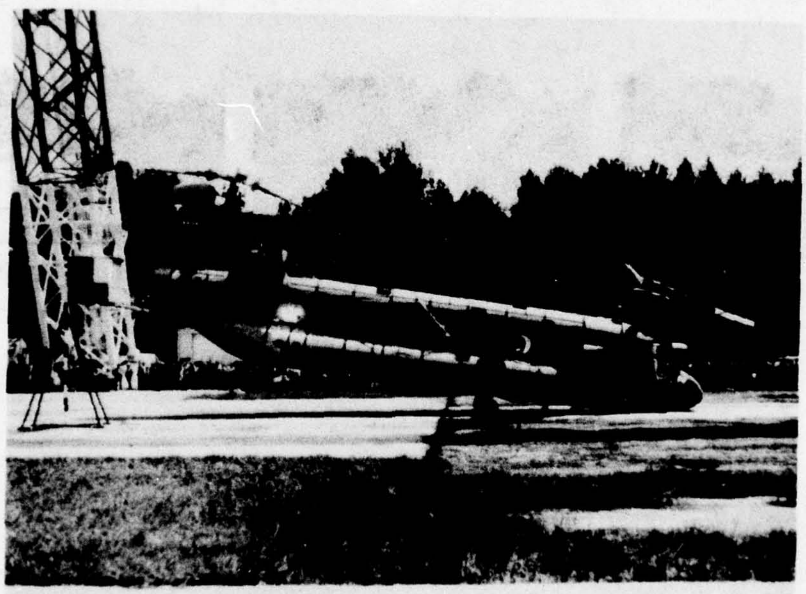

Figure 16. CH-47A Crash Test .035 Second After Impact.

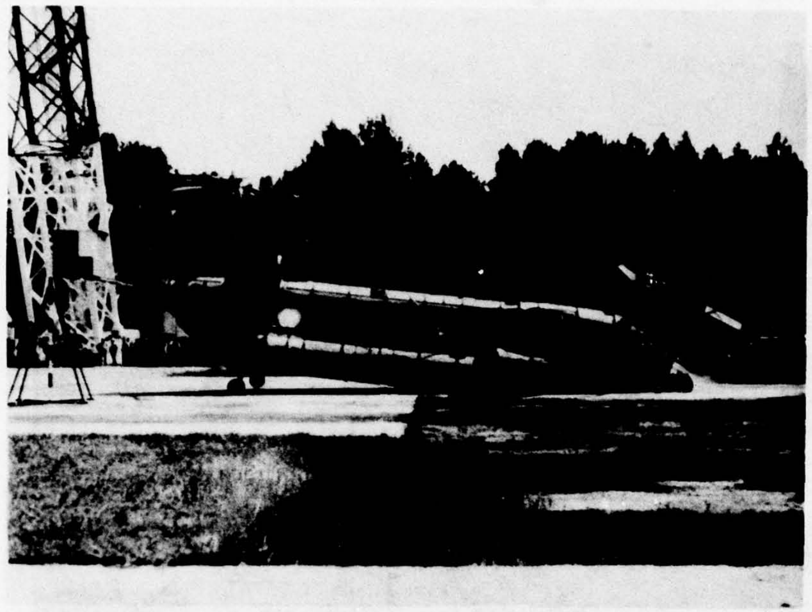

Figure 17. CH-47A Crash Test .085 Second After Impact.

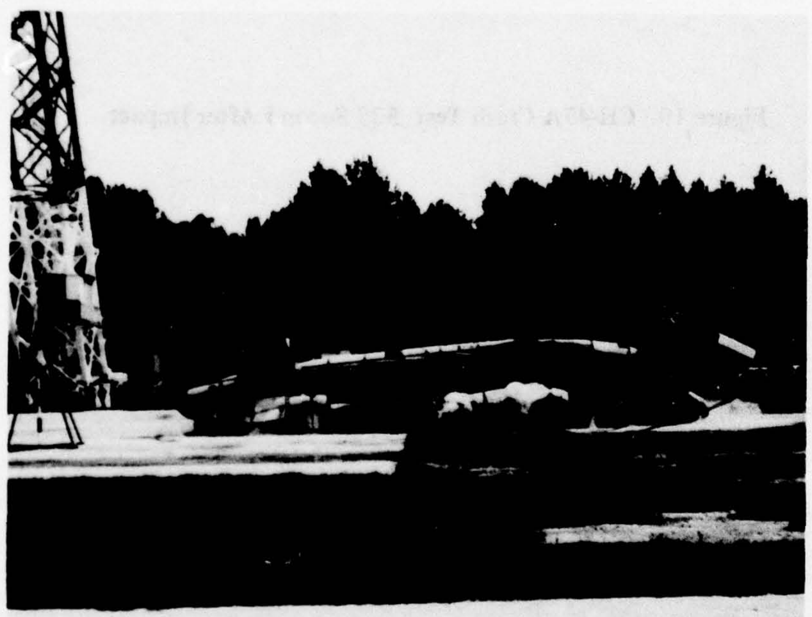

Figure 18. CH-47A Crash Test .235 Second After Impact.

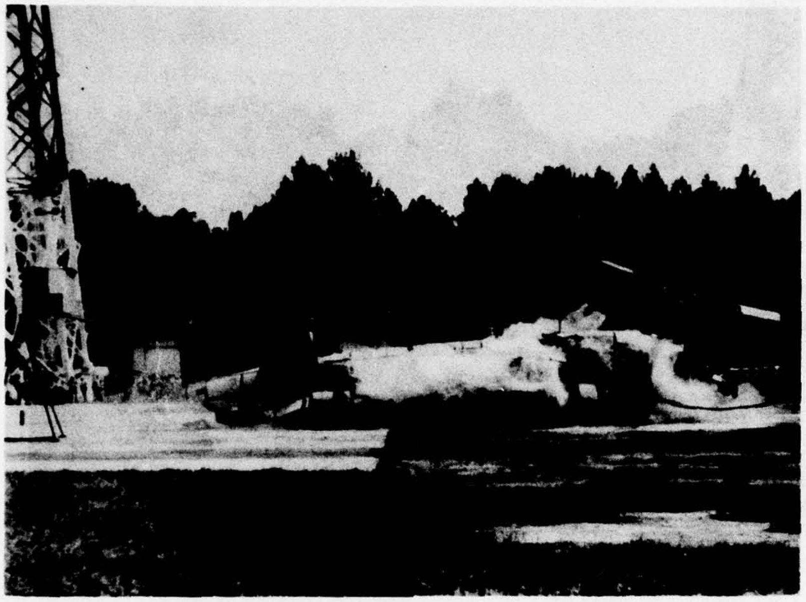

Figure 19. CH-47A Crash Test .535 Second After Impact.

All major concentrated mass items such as hubs, shafting, transmissions, and engines maintained their structural integrity throughout the entire crash sequence. It is worth pointing out here that the support structures for these items are designed to provide static retention strength for crash load factors of 8 'g's applied independently in the three principal directions. Both aft landing gears appeared to fail almost immediately upon ground contact. Later examination of the associated aft fuselage area showed that the structural torque box supporting the landing gear and the oleo attachments had failed. The aft pylon area was virtually intact and the available opening at the aft ramp was sufficient to permit occupant egress.

The test article was carefully inspected after the impact test to identify structural failures. Photographs showing failure modes at significant structural areas were obtained. The results of this inspection are briefly discussed below.

4.4.1 Review of Structural Damage

Figure 20 shows the right side of the forward fuselage and cockpit areas. From an outward view it can be seen that most of the damage is due to the crushing of the underfloor structure. The crown and side skin area were generally undamaged except for the outward buckling of the cockpit door coaming members. The forward pylon area, see Figure 21, was virtually undamaged. Blade damper attach lugs on one pitch housing had failed; this failure was, however, not due to crash loads but was caused by one of the swing cables snagging the stub blade during release and causing an overload condition for the damper attachments. The extensive structural damage sustained by the cockpit floor as a result of crushing can be seen in Figures 22 and 23. Both pilot and copilot seats showed failures in the pan attachment areas under the crash-induced vertical loading. The CH-47A seats are not crash-force-attenuating crew seats. The right seat back upper part sustained a torque-induced shear failure. Also, it can be seen from the figures that the shear web, F.S. 95 bulkhead right side collapsed, forming a shelf 5 inches deep, approximately 6 inches below the kink point. It is believed that this failure was actually caused by test fixturing and as such not pertinent. As noted previously, the jettisonable door coaming member on the right side buckled and the attached skin sheared aft at its attachments to the F.S. 95 bulkhead, as shown in Figure 24. Some damage was caused to the right and left buttline beams and control closet support structure adjacent to the left buttline beam, as shown in Figures 25 through 27. There was some evidence to indicate that the damage was caused by the forward trailer (cargo experiment) impacting this structure during the crash sequence, causing it to rotate inward and forward.

The most extensive structural damage occurred around the main landing gear support structure area, fuselage station 240. General external views of damage to the primary structure and fuel pods are shown in Figures 28 through 30. The structural failure of the fuselage side panel was predicted. The main landing gears and their local attachments to the structure between F.S. 240 and F.S. 260 were intact. However, the lower longeron/skin panel sections which transmit the bending loads from the landing gears into the center fuselage area had failed primarily

Figure 20. CH-47A Crash Test – Damage to Forward Fuselage on Right Side.

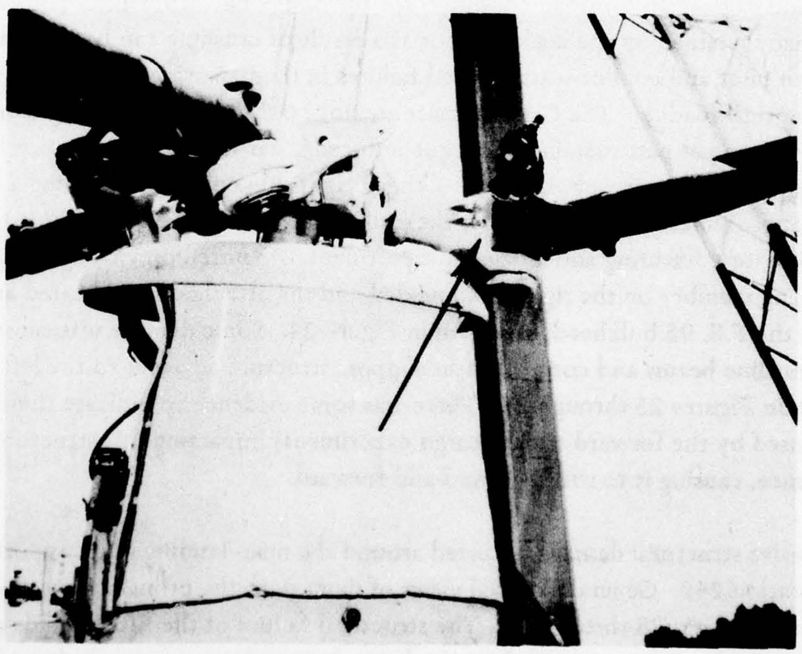

Figure 21. CH-47A Crash Test – Forward Pylon Area.

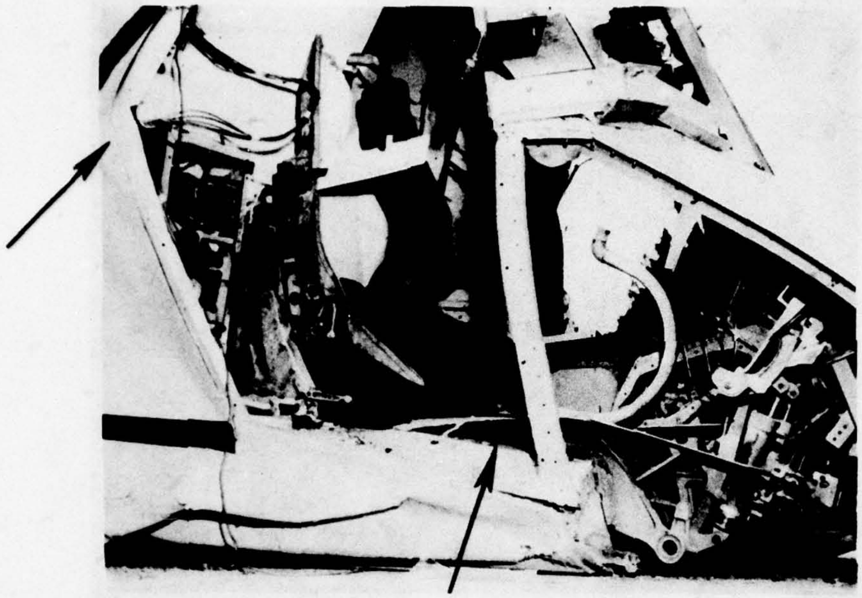

Figure 22. CH-47A Crash Test Structural Damage in the Cockpit Floor Area.

Figure 23. CH-47A Crash Test – Failures of Crew Seat Pans and Airframe Structure

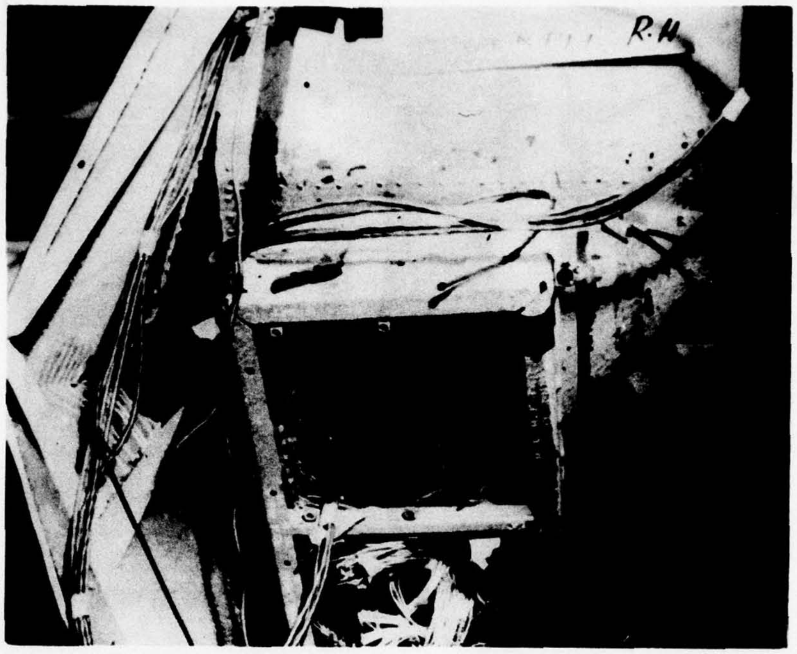

Figure 24. CH-47A Crash Test – Shear Failure of Side Skin, Right Cockpit.

Figure 25. CH-47A Crash Test – Structural Damage – Right Buttline Beam.

Figure 26. CH-47A Crash Test Damage to Frame 120 and B.L. 18 Beam Due to Impact by Forward Trailer Experiment.

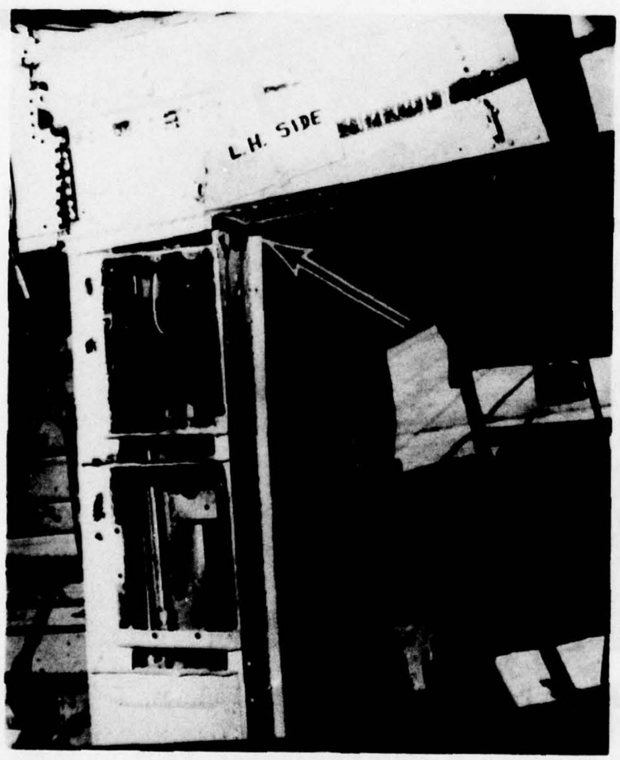

Figure 27. CH-47A Crash Test – Structural Damage Control Closet Area (Lower).

Figure 28. CH-47A Crash Test – General View of External Damage to the Center Fuselage Right Side.

Figure 29. CH-47A Crash Test – Side Skin Panel Rupture and Shear Failures, F.S. 240, Right Side.

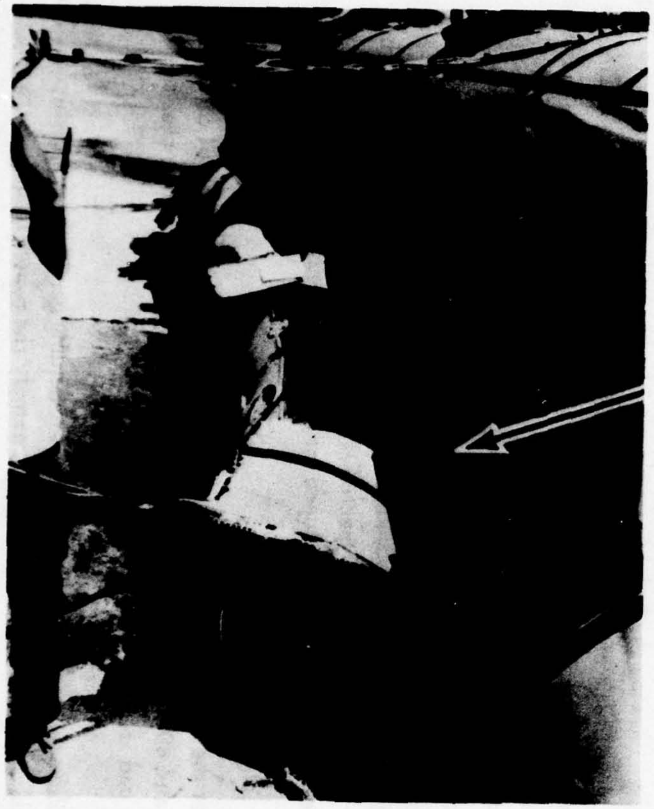

Figure 30. CH-47A Crash Test – View Showing Fuel Pod Separation and Failures Aft of F.S. 240, Right Side.

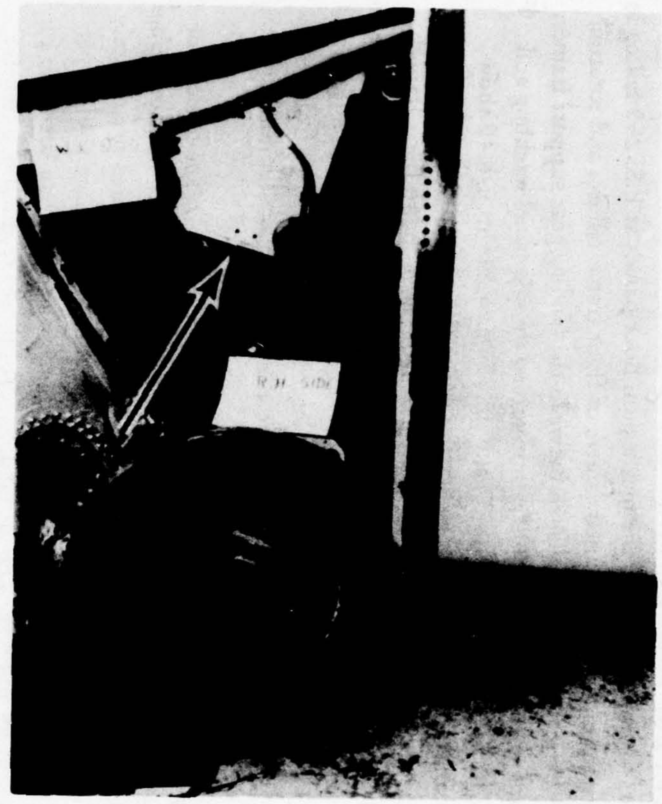

Figure 31. CH-47A Crash Test – Details of Failures in Right Main Landing Gear Support Structure Area.

in a shear mode as shown in Figures 31 through 33. These failures, coupled with the failure of the floor frame corner joint area (Figure 23), permitted the landing gears to rotate into the main fuel pods. Figures 34 through 36 show the magnesium floor panels at F.S. 240 failing in primary longitudinal tension under the combined effects of floor frame failures and rotation and rupture of the lower half of the structural shell between the landing gear support frames. The side frame joint to the crown at Station 200 failure forced by side panel buckling and ruptures aft of Station 240 are shown in Figures 37 and 38. Figures 39 through 42 show general views of the cabin interior structure up to Station 440. This area suffered very minor damage caused mainly by the intrusion of the floor into the cabin area due to floor frame corner joint failures. The crown structure aft of Station 280 was virtually undamaged, as were the magnesium floor panels. This is understandable as, in general, the only external loads which the crown structure generally sees during the impact are due to the inertia from the local structural mass. This mass is very small compared to the aircraft mass distribution.

External views of the aft fuselage structure are shown in Figures 43 and 44. The basic structure in the aft pylon area showed almost no damage except for local skin wrinkling and some deformation in the aft fairing area. As noted earlier, the aft landing gears failed prematurely, causing the ramp structure to impact the ground. This resulted in local damage to the open frames aft of F.S. 482. In spite of this, over-the-ramp clearance was more than adequate for occupant egress (see Figures 39 and 43). The aft landing gear failures resulted in extensive structural damage to the landing gear support structure (torque box) and fairings. Details of this damage are shown in Figures 45 through 47. Based on examination of the test aircraft and evaluation of the pictures, it appears that the outboard edge member attachment hole areas at Station 482 failed initially, allowing the bulkhead web to rack about the inboard cap edge and causing a tearing type failure of the entire web (see Figure 45). This destroyed the bulkhead's capability to resist pitching moments and allowed the gear unit to rotate about the upper shock strut attach point without the landing gears' developing a significant load on ground contact. Consequently, Station 482 bottom fuselage area contacted the ground, producing very high forces and causing the secondary damage seen on the torque box/fairing area in the figures. In general, the failures in the support areas on both right and left sides were very similar. Both analysis and prior test data show that the weak links in the aft landing gear structure are the shock strut upper cover and lug areas. It is suspected that the failures in this crash test may have resulted from structural weaknesses introduced into the test aircraft after its retirement from active fleet.

The internal structure of the aft pylon showed no significant damage as a result of the crash impact (see Figures 48 and 49). The right engine installation in Figure 50 shows that the engine aft support mount pad area had failed in tension.

To summarize, gross failure mechanisms, except at the aft landing gear, were as predicted. The most severe structural damage was found in two areas, namely the center fuselage between Stations 200 and 280 and the cockpit/nose section. The primary damage was confined to the

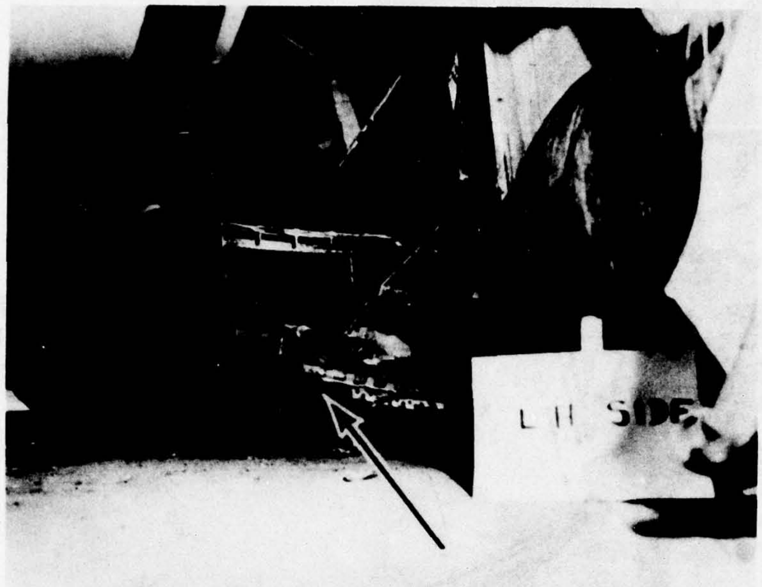

Figure 32. CH-47A Crash Test – View Showing Lower Fuselage Rupture in the Main Landing Gear Support Area.

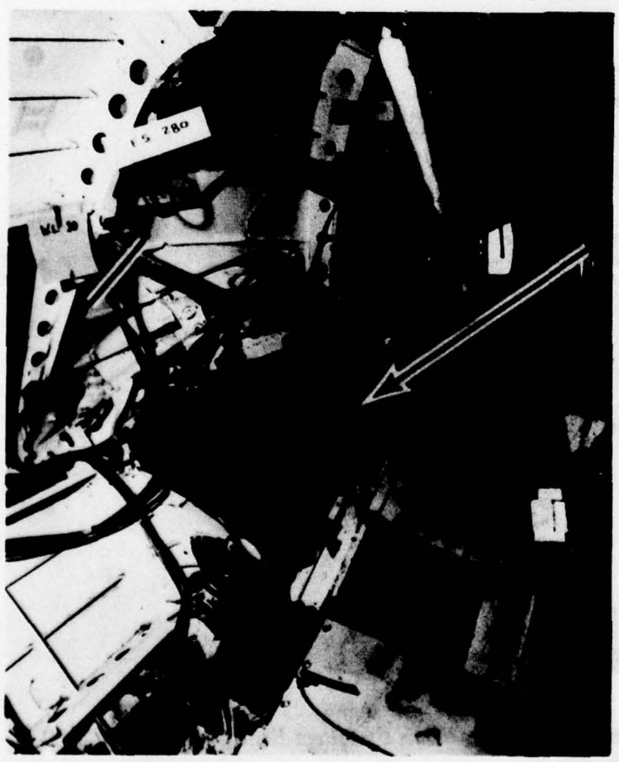

Figure 33. CH-47A Crash Test – Floor Frame and Floor Failure Details, F.S. 260 Area.

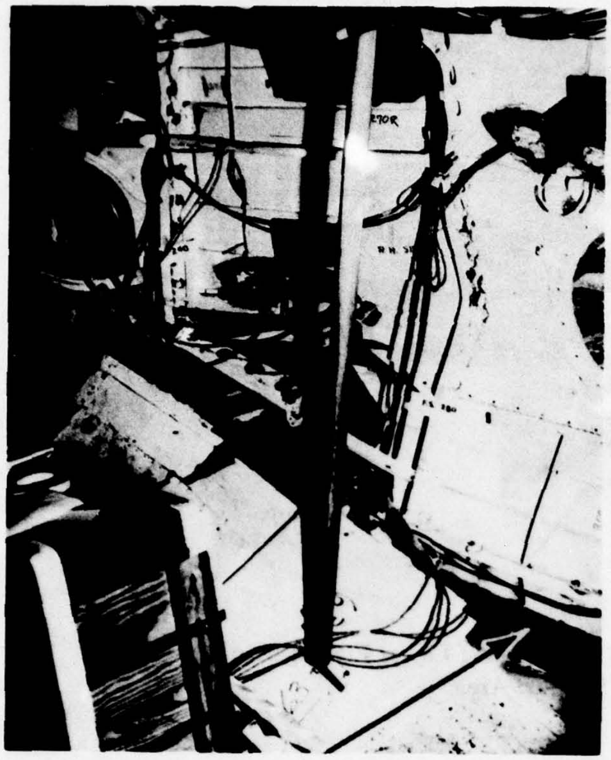

Figure 34. CH-47A Crash Test Separation of Floor and Fuselage Shell on Right Side Between F.S. 240 and 300.

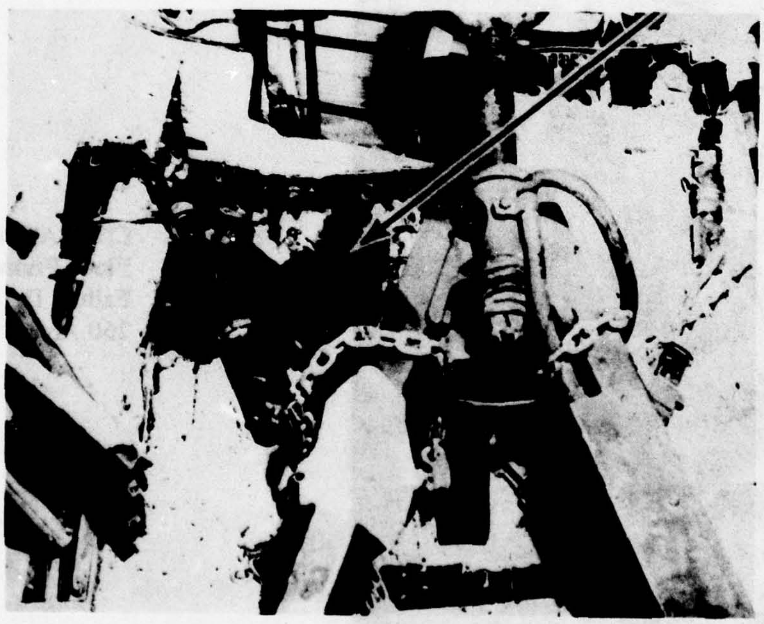

Figure 35. CH-47A Crash Test – Floor Panel Failures Between Fuselage Stations 180 and 280.

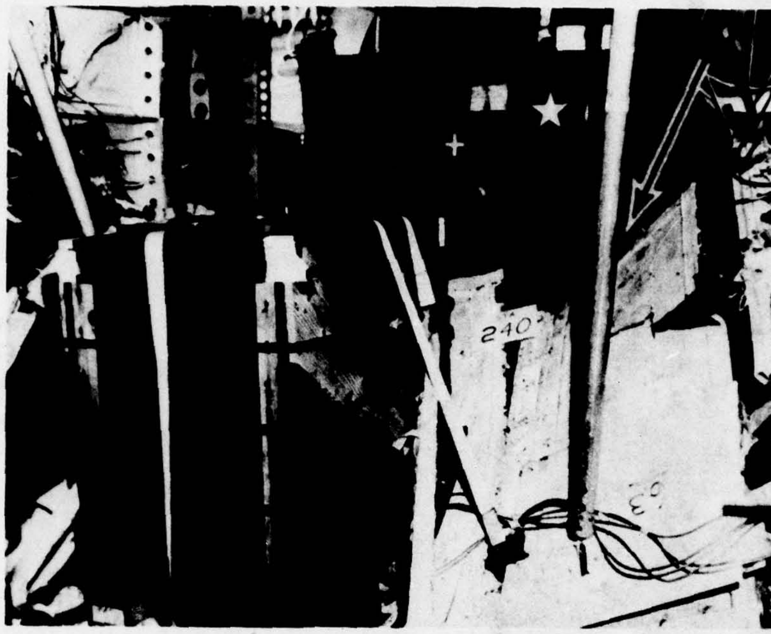

Figure 36. CH-47A Crash Test – Damage to Floor in Area of Main Landing Gear (View Looking Forward).

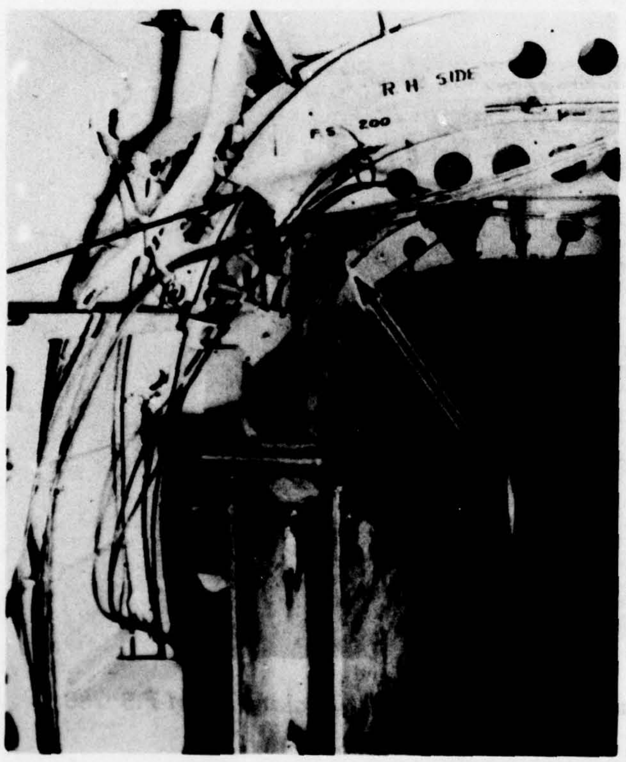

Figure 37. CH-47A Crash Test Damage to Frames, Skins, and Longerons on Right Side Aft of Station 180.

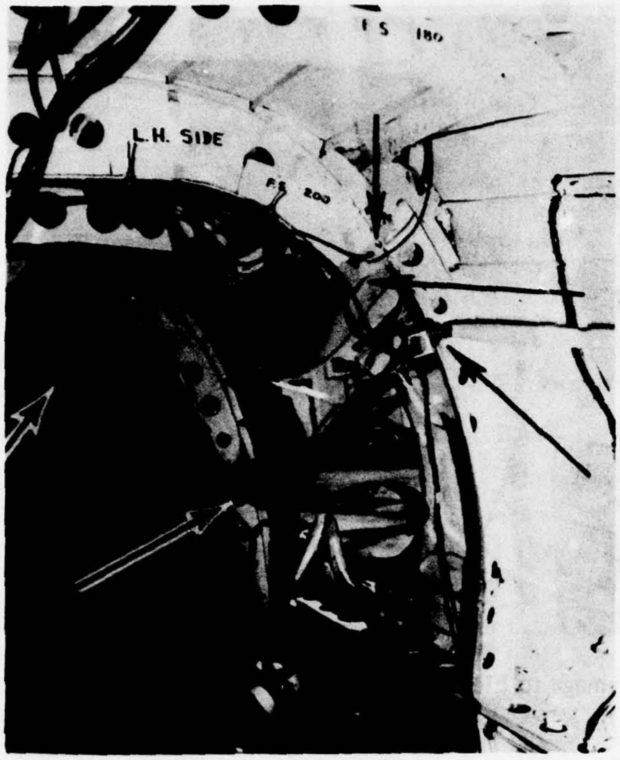

Figure 38. CH-47A Crash Test Damage to Frames, Skins, and Longerons on Left Side Aft of Station 180.

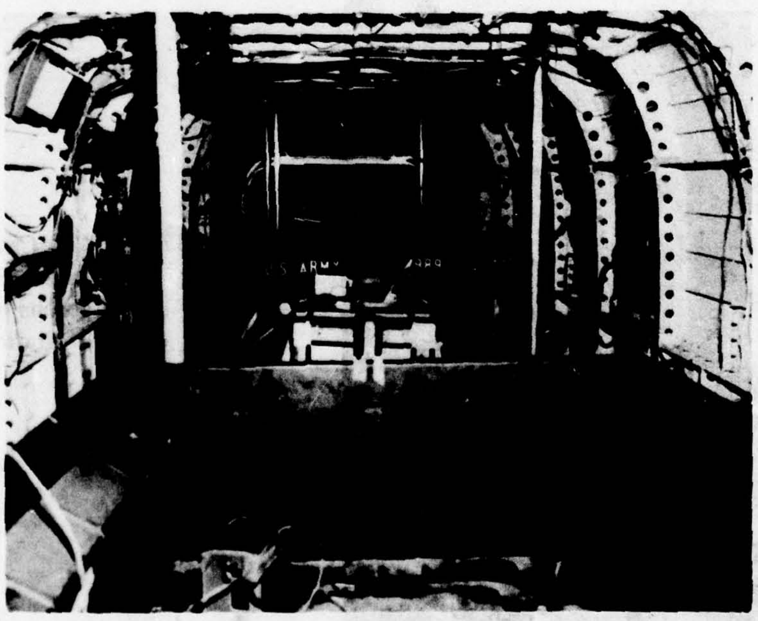

Figure 39. CH-47A Crash Test – General View of Cabin Interior Looking Aft of F.S. 280.

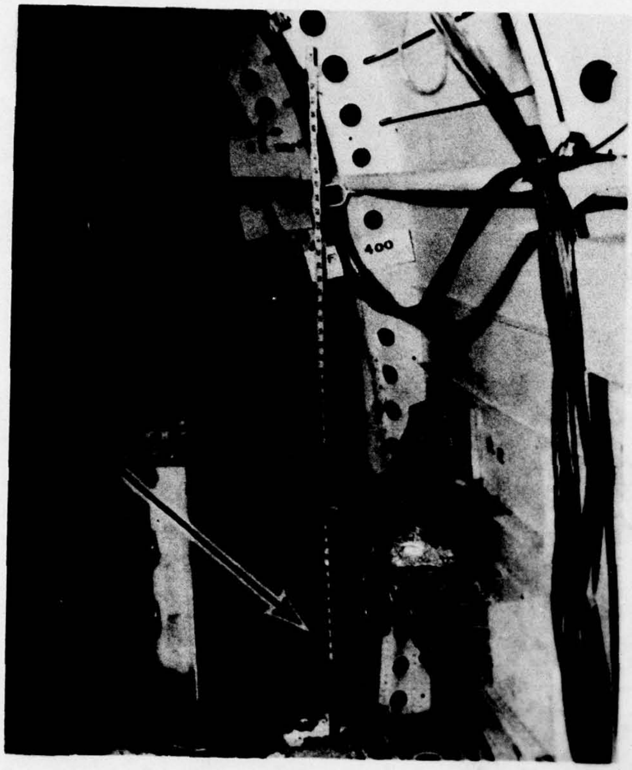

Figure 40. CH-47A Crash Test – Damage to Frames, Skins, and Longerons, Right Side Forward of Station 440.

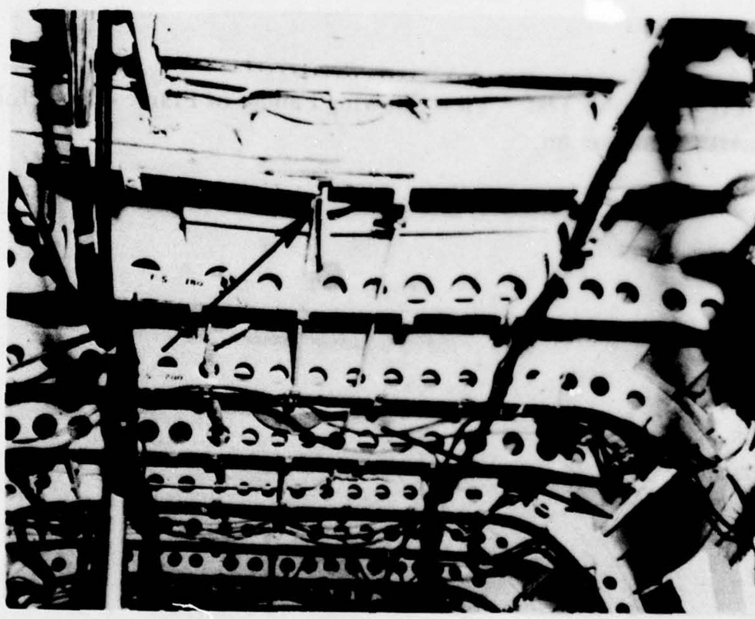

Figure 41. CH-47A Crash Test – Details of Structural Damage in Cabin Crown Area.

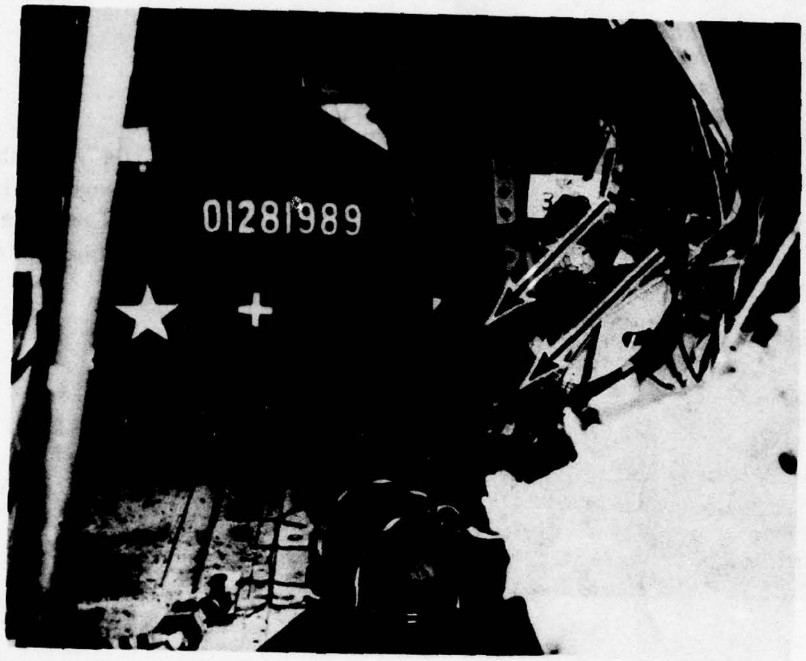

Figure 42. CH-47A Crash Test – View Showing Failure of Frame Corner Joint Area, Aft Cabin Section.

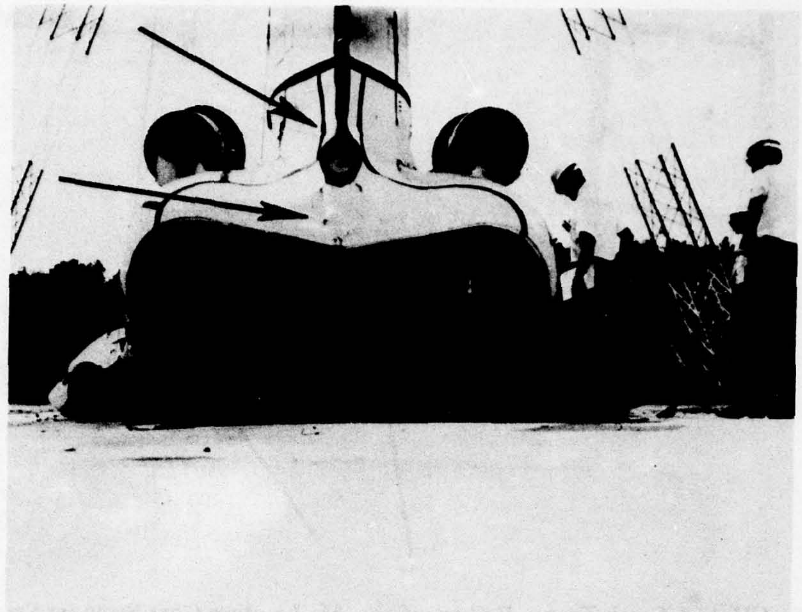

Figure 43. CH-47A Crash Test – View Looking Forward Showing Egress Clearance Over the Ramp.

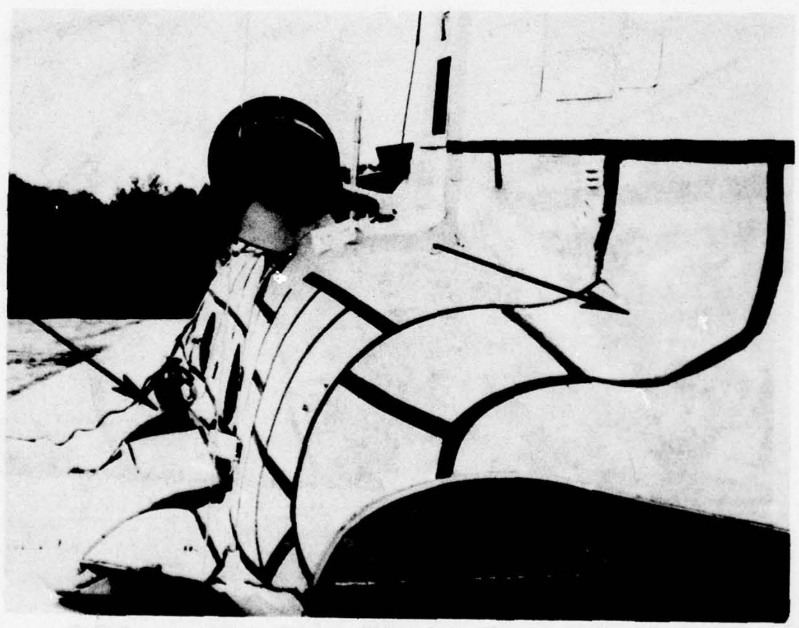

Figure 44. CH-47A Crash Test – External Damage to the Left Aft Pylon Structure.

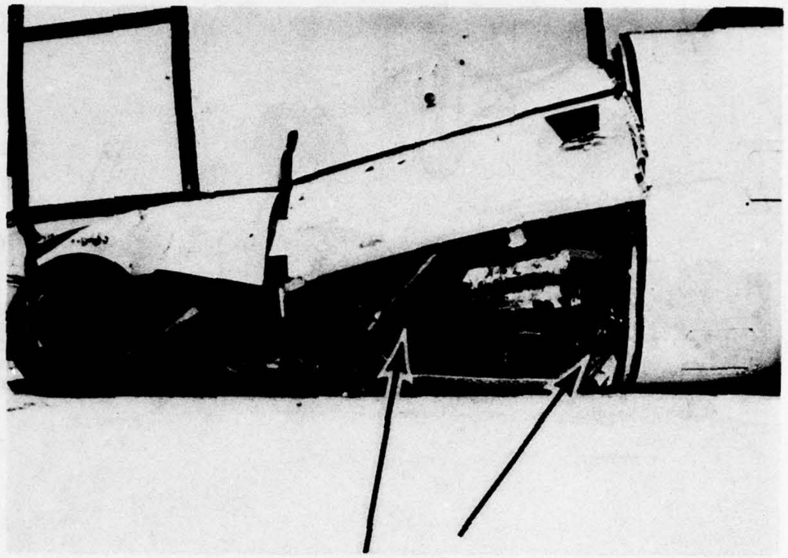

Figure 45. CH-47A Crash Test – Failure of the Aft Landing Gear Support Structure Area.

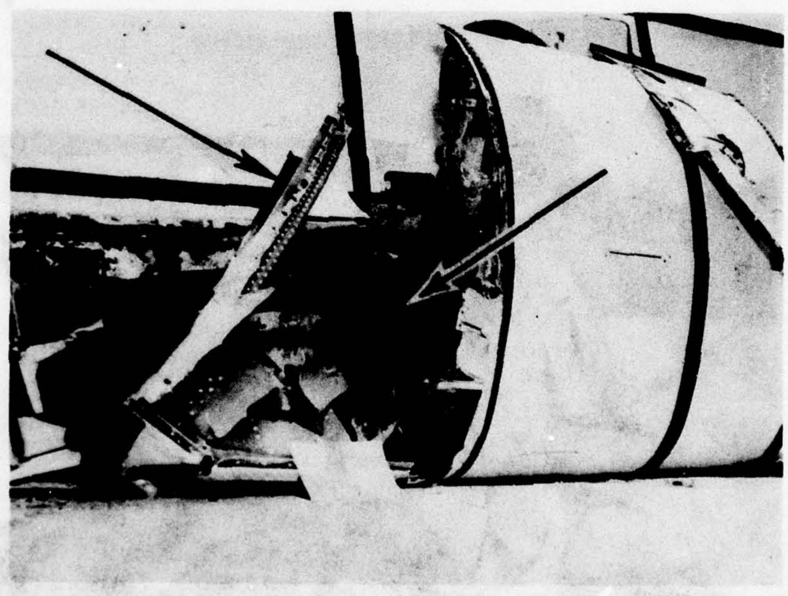

Figure 46. CH-47A Crash Test – Details of Torque Box Structural Failures at F.S. 482.

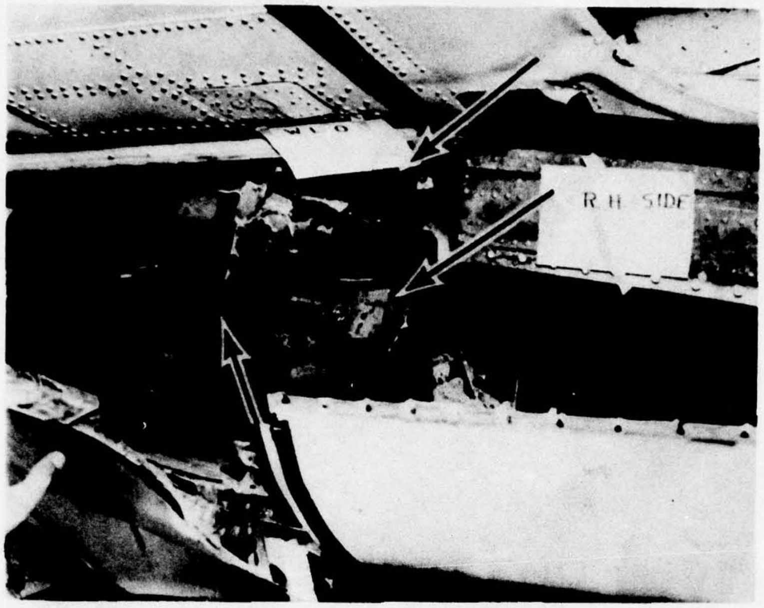

Figure 47. **CH-47A Crash Test – View Looking Down at the Aft Landing Gear Support Structure Area.**

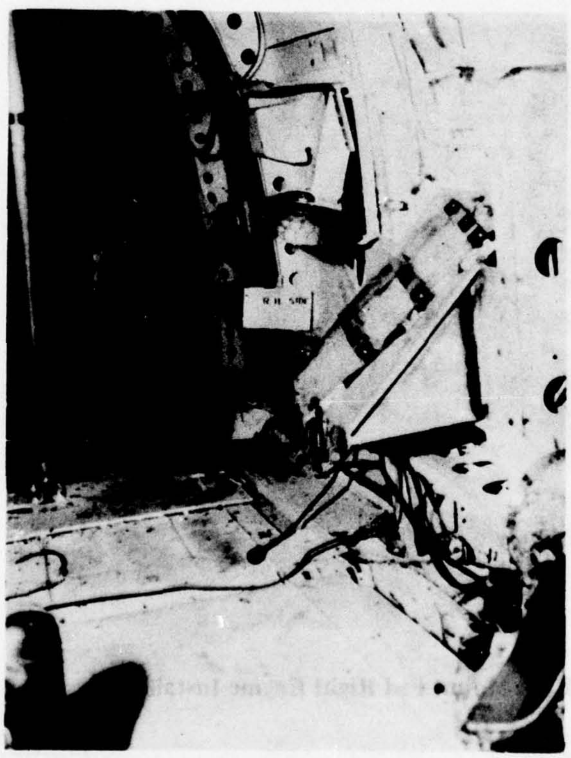

Figure 48. **CH-47A Crash Test – Interior View of Right Side of Aft Fuselage Internal Structure and Ramp.**

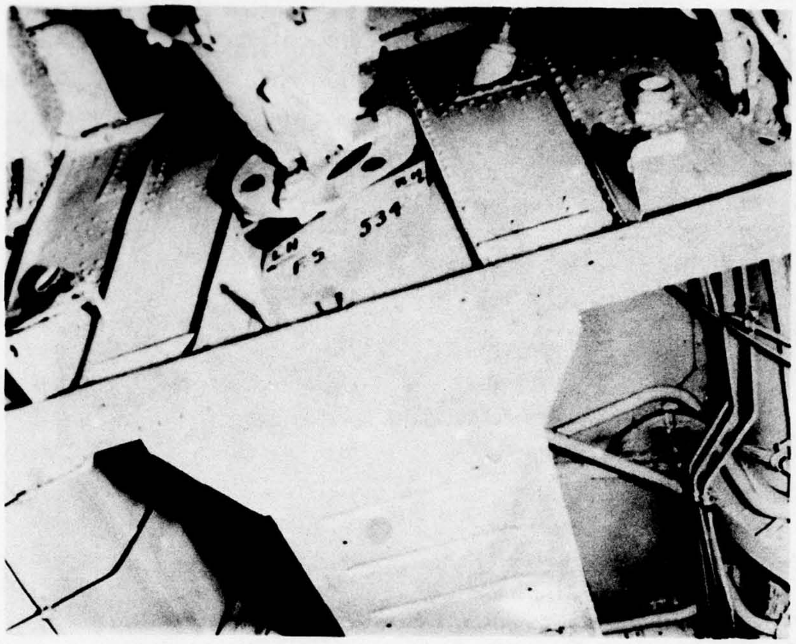

Figure 49. CH-47A Crash Test – No Damage to Primary Structure in Aft Pylon Splice Area F.S. 534, Below W.L. 72.

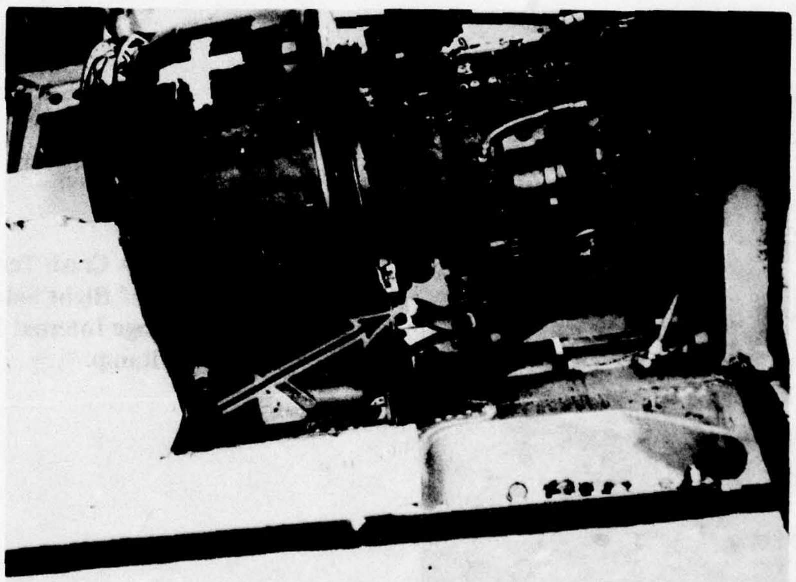

Figure 50. CH-47A Crash Test – Failure of Aft Mount Pad Right Engine Installation.

bottom fuselage area and, in the center fuselage area, the damage resulted in intrusive failure of the floor panels. In the rest of the cargo compartment structural damage was extremely limited. The structural failures aft of Station 280 indicated no potential for mechanically induced injuries to surviving occupants. Residual cabin height measurements indicated acceptable reductions in inhabitable volume and indicated that occupants in these areas, if seated in crashworthy seats and properly restrained, would have a high probability of survival. Further, egress of the survivors by the main cabin doors and over the ramp area was possible.

4.5 TEST DATA ANALYSIS

Motion picture and raw instrumentation data were reviewed to provide preliminary information regarding impact conditions, aircraft states, and approximate maximum acceleration levels. The data acquisition system performed excellently. The instrumentation failure rate was very low. Data from a few channels were lost as a result of wire severance or local damage during impact. Both pressure transducers in the fuel cells were lost immediately after impact due to main landing gears rotating into them. The test results indicated that the static crash load factors used in the design of the retention structure for major mass items provide adequate strength for the loads induced during a 95th-percentile survivable crash impact.

The data indicated that, at the time of the aft landing gear failure, the accelerations and loads in the landing gear and its support structural areas were well below design structural strengths. These design strength levels have been substantiated during both qualification testing and subsequent structural flight tests. At this time, the failed areas were reexamined. It was found that the torque box structural attachments at the aft bulkhead had failed in shear and the upper airframe fitting for oleo attachment had failed under the combined action of lateral loading and torsion. However, the fitting failure is suspected to have occurred during the removal of the crash test wreckage from the test site. (See Figure 47, which shows no failure in this area.)

Table 4 provides an event summary obtained from a frame-by-frame analysis of the motion picture data showing the time after impact for primary ground contacts and structural failures.

The raw data acquired during the test was filtered through a 100-Hz low-pass digital filter and further processed to obtain accelerations, velocities, displacements, stress, and loads at the gage locations. The filtered data set is included for reference purposes in Appendix C. The approximate values for peak 'g' levels and associated pulse duration for selected locations are given in Table 5. These values can be used for crash impact analyses.

4.6 DETERMINATION OF IMPACT CONDITIONS

Several alternative approaches had to be used to define the velocities and attitude at impact of the test aircraft. These included analyses of motion picture data and radar data.

TABLE 4. CH-47A CRASH TEST – SUMMARY OF PRINCIPAL EVENTS FROM FILM ANALYSIS

Time After Impact (seconds)	Event
0.00	Forward landing gear impact
0.025	Fuselage nose section contact
0.035	Fuselage ground contact up to F.S. 120
0.040	Side skin F.S. 240-280 begins to buckle
0.050	Center window area F.S. 260 distorted
0.060	Side skin F.S. 240-280 deeply buckled with buckles extending below W.L. 0
0.070	Underfloor structure in cockpit area crushed Side skin buckled up to F.S. 160 Main landing gear attachment failed Structure above windows considerably deformed
0.080	Fuselage shell ruptures diagonally on left side F.S. 200-280
0.085	Aft landing gear impact
0.090	Fuselage/ground contact up to F.S. 280 Floor crushed to F.S. 260 Tunnel covers fuselage crew area separates to F.S. 280
0.0975	Fuselage/ground contact up to F.S. 320
0.110	Skin buckled across F.S. 320
0.1225	Total failure aft landing gear Fuselage/ground contact up to F.S. 482

TABLE 5. CH-47A CRASH TEST – ACCELERATIONS DUE TO IMPACT AT SELECTED LOCATIONS

Item	Location			Vertical				Longitudinal			
				High Frequency[a]		Low Frequency[b]		High Frequency[a]		Low Frequency[b]	
	Sta	WL	BL	Max g	ΔT_1	Max g	ΔT_2	Max g	ΔT_1	Max g	ΔT_2
Pilot Seat Floor, Right	75	–25	24	58	0.010	27	0.058				
Pilot Seat Floor, Left	75	–25	–24	–	–	–	–	140	0.009		0.070
Pilot Scat Pan, Right	80	–10	24	48	0.017	34	0.070	50	0.010	24	0.065
Pilot Seat Pan, Left	80	–10	–24	50	0.010	25	0.070	50	0.011	34	0.080
Forward Transmission	110	60	0	–	–	–	–	9	0.012	4	0.0
Forward Trailer Floor	165	–30	0	92	0.007	62	0.075	61	0.010	44	0.085
Forward Pallet Floor	280	–30	0	180	0.008	45	0.065	105	0.010	26	0.070
Baseline Cargo	320	–18	33	110	0.010	22	0.100	58	0.010	14	0.070
Aft Trailer Floor	370	–30	0	130	0.010	31	0.040	19	0.010	6	0.075
Aft Pallet Floor	460	–30	0	60	0.010	24	0.075	120	0.014	77	0.090
Engine, Right	496	80	48	40	0.011	24	0.060	12	0.019	–	–
Engine, Left	496	80	–48	42	0.010	18	0.090	24	0.014	12	0.090
Mix Box	455	68	0	–	–	–	–	12	0.012	6	0.090
Aft Transmission	540	68	0	16	0.016	8	0.140	9	0.020	4	0.130

NOTES: a. Oscillatory accelerations within the frequency range of 50-100 Hz

b. Estimated equivalent acceleration pulse with a duration greater than 0.05 second

c. ΔT_1 and ΔT_2 are pulse widths assuming triangular pulse shape.

At Boeing Vertol, the high-speed movies were used for this purpose. Individual frames were projected using a time and motion analysis projector. Selected points on the aircraft and ground reference points were mapped for each frame. Approximately 4,000 points were thus obtained. Time relationships were established from the filming speed of 400 frames per second and frame count. From this data, it was possible to calculate relative displacements, velocities, and accelerations at the selected points on the aircraft. This required a horrendous amount of data processing. In order to reduce the effort required to reduce this data, several computer programs were written to first calculate the displacements of the points on the aircraft with respect to ground and then, using an 8th-order polynomial regression analysis routine, establish the coefficients for the vertical and horizontal displacement curves. The first and second derivatives of the displacement curves established the velocities and accelerations. This data was used to estimate the actual impact conditions.

The estimates together with results of similar analyses, radar data, and motion synthesizer studies by the Applied Technology Laboratory and NASA/LRC were utilized to define the actual test impact conditions shown in Table 6.

TABLE 6. CH-47A CRASH TEST IMPACT CONDITIONS

Item	Planned	Actual*
Gross Weight (lb)	24,300	25,010
CG (fuselage station)	328.5	323.7
Contact Velocity (fps)		
Vertical	42	43.5
Longitudinal	27.1	28.3
Lateral	0	0
Resultant	50	51.25
Attitude (deg)		
Roll	0	0
Pitch (nose down)	5	8.7
Yaw	0	0

*Test impact velocities and attitude are based on motion analyses and radar data.

5.0 TEST SIMULATION AND MODEL IMPROVEMENTS

5.1 REVIEW OF PRETEST PREDICTIONS

Following the crash test, the CH-47A KRASH model was resimulated for the target impact conditions using a constant iteration interval. Predicted vertical and longitudinal accelerations for 25 masses, located on the centerline and on the left side of the model, were filtered using the 100-Hz low-pass digital filter. The time histories for these accelerations are included in Appendix B.

Although the impact conditions used for the simulation differed from the actual test conditions to some degree, it is considered that the dynamic responses should be comparable. Hence, in order to identify model improvements prior to detailed test simulation, correlation studies were performed.

The studies indicated:

- Fair agreement in occurrences of ground contact and major structural states. Figure 51 shows this comparison between actual and predicted data in the form of an event summary.

- Predicted accelerations and displacements correlate poorly with the corresponding data from the test.

5.2 TEST SIMULATION

5.2.1 Updated Model and Simulation

Based on the review of the pretest predictions and test data, the CH-47A (KRASH) model was modified as follows:

- The mass distribution was revised to reflect the final gross weight and c.g. position of the test article.

- The ground friction factors at the ground springs representing landing gears and fuselage underbody were decreased to better approximate friction effects of the concrete test impact area.

- The aft landing gear area stiffness and strength factors were adjusted to account for test failure modes.

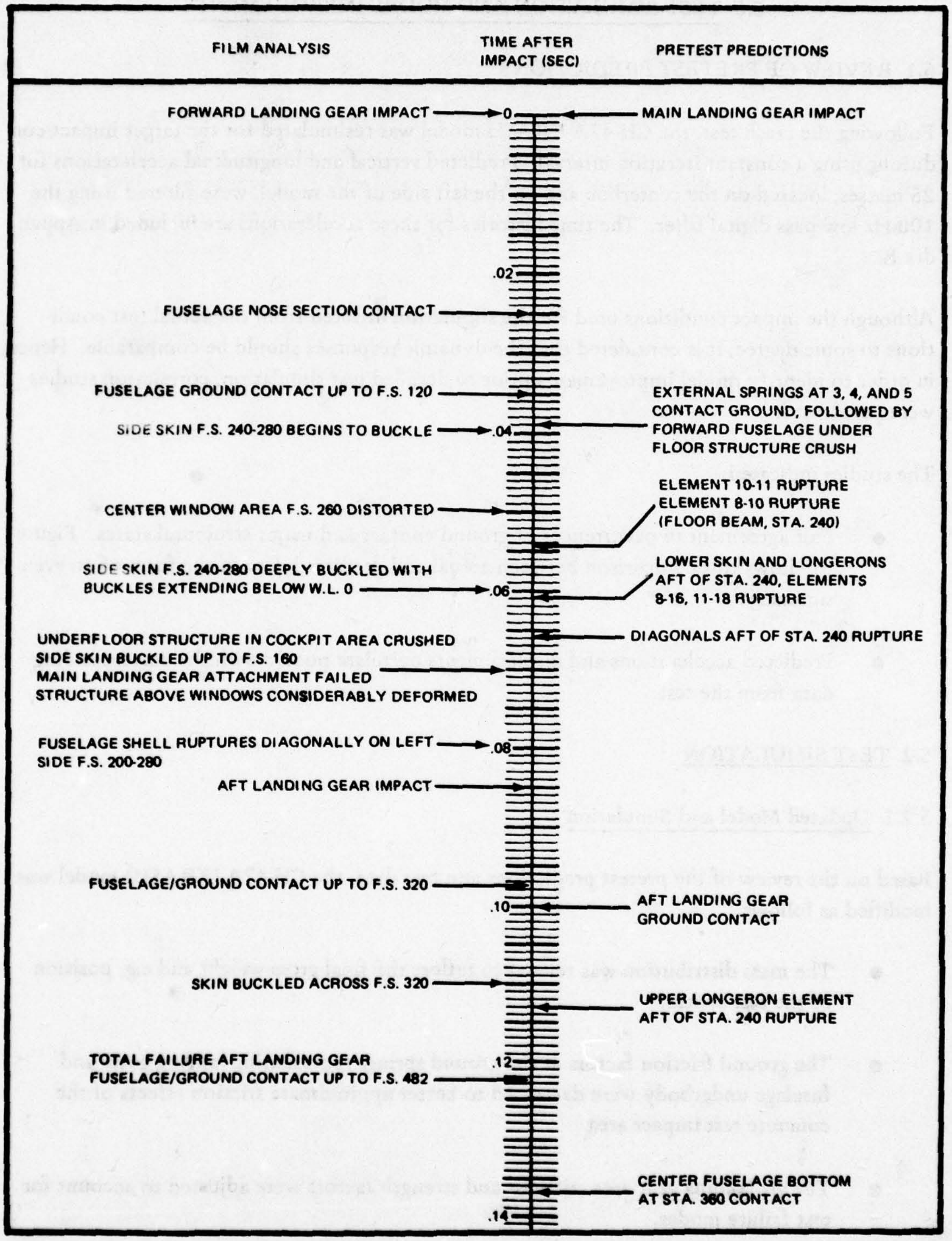

Figure 51. Event Chronology of Pretest Model of CH-47A Crash Test Simulation.

- Some minor changes in definition of one-sided elements were made in the model.
- Initial conditions for simulation were redefined to reflect actual test impact conditions.

Additional runs were conducted using the S-79 computer program. This permitted more meaningful correlation of data and evaluation of KRASH program logic as well as modeling deficiencies since both predictions and test data would be based on the same initial conditions.

Several of the problems in program logic identified during these studies were:

- The total energy was not constant within acceptable limits. This indicated that the solution process was unstable and energy was being pumped into the system.
- The KRASH predictions were extremely unsymmetric. This included unsymmetric deflections of corresponding points on opposite sides of the airframe. The model also developed a small lateral velocity (i.e., drifting to one side).
- The forward velocity, instead of decaying monotonically to zero, reversed and increased in the rearward direction.
- The model exhibited a skating phenomenon subsequent to initial rebound.

5.2.2 Discussion of Program-Related Problems

The first of the above problems is discussed in detail in Section 3.4.

In an effort to solve the second and third problems, which are related, several detailed investigations were initiated. The first involved a simple, fully symmetric, four-prong model in the form of a '+' with a mass and ground spring at the extremity of each arm and a mass at the center (see Figure 52). This model was used to simulate a vertical 1g impact. The KRASH code predicted that the model would rebound upward well above the initial release point, while drifting to one side, and subsequently flip over. This result is in violation of all known physical principles. Further, the predictions varied with model azimuth orientation and/or nodal numbering sequence. A detailed analysis of the logic blocks in DERIV subroutine of KRASH identified the source of the problems to be incorrect beam element force and moment relationships and errors in the derivation of mass accelerations in the moving system.

Required corrections were incorporated into KRASH (S-79) in a parallel effort under Contract DAAJ02-75-C-0014. The corrected program is identified as S-79 TEMX. Details are reported in Reference 3.

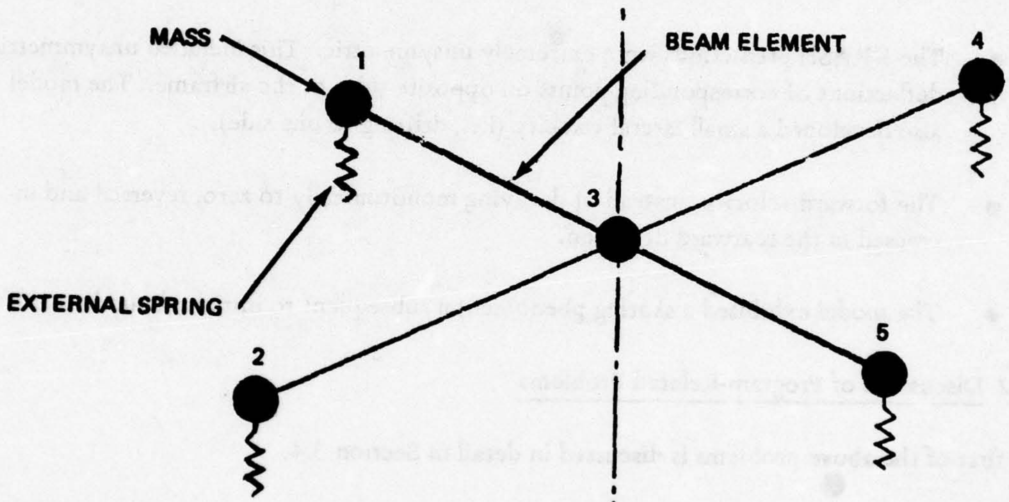

Figure 52. Schematic of Cruciform Model Used to Investigate Integration Problems in KRASH.

The next problem investigated was the skating phenomenon. The term skating is applied here to describe the analytical phenomenon that occurs in KRASH after a structural model rebounds on its external (ground) springs. As a ground spring extends during the initial rebound, the spring unloads rapidly to zero. The spring loads stay at a zero value as the spring continues to extend. Thus, for a significant length of time, i.e., until the next reloading cycle compresses the external spring beyond the deflection at which the previous rebound occurred, no external forces are input from this spring to the model. As, in the model, several external springs experience this condition concurrently, it skates during this time. The model velocities stay essentially constant except for the effect of gravitational acceleration on the vertical velocity. This phenomenon is illustrated in Figure 53. During the initial power stroke of the external springs representing the main landing gear and the forward fuselage crushable underfloor structure, the vertical velocity at the model center of gravity decreases rapidly. However, as each of these springs unloads as the forward fuselage section rebounds, the rate of deceleration of c.g. velocity decreases. Finally, as the spring at node 3 unloads fully, the velocity is seen to stay virtually constant from about t = 0.07 second to t = 0.12 second when the 'main landing gear' spring starts to reload. Also, the vehicle energy showed rapid and fairly large changes during these unload-reload intervals.

A careful analysis of the methodology employed in KRASH for calculating external spring loads showed that this element can be useful for representing crushable structure provided that, in the impact dynamics of the aircraft modeled, almost all the crash impact energy is absorbed during the first power stroke. Representation of an oleo landing gear behavior is beyond its capability.

Figure 54 shows a typical load-deflection characteristic for an external spring used in the KRASH model. To demonstrate the basic problem in the program logic, see Figure 55, two very similar cases will be considered. The first case displayed in Figure 56 represents a spring deflecting monotonically from zero to 'S'. The external spring forces then correspond to the point 'g' on the K_e portion of the characteristic. The second case illustrated in Figure 57 represents a spring deflecting an arbitrary amount less than S_B, at which time a small deflection reversal is assumed to occur. Following the reversal, the spring is deflected monotonically to the point 'S'. The final spring force is the same for both cases being considered. The shaded areas under the respective curves represent the energy inputs from the two cases into the system. It is readily seen that the energy in the two cases is radically different, although in actual practice the two would be almost identical.

A more detailed, step-by-step examination of the deflection curve for the second case helps to explain the error in the algorithm used for ground springs in the KRASH code. Again referring to Figure 57, as the spring deflection increases, the load is increased along the curve a-b-c-d, at which time the spring starts unloading. Using the algorithm shown in Figure 55, the program calculates the spring load going to zero along d-h with a slope equal to K_e and then continues along h-a. On the next loading cycle, the spring load is maintained at zero until point h.

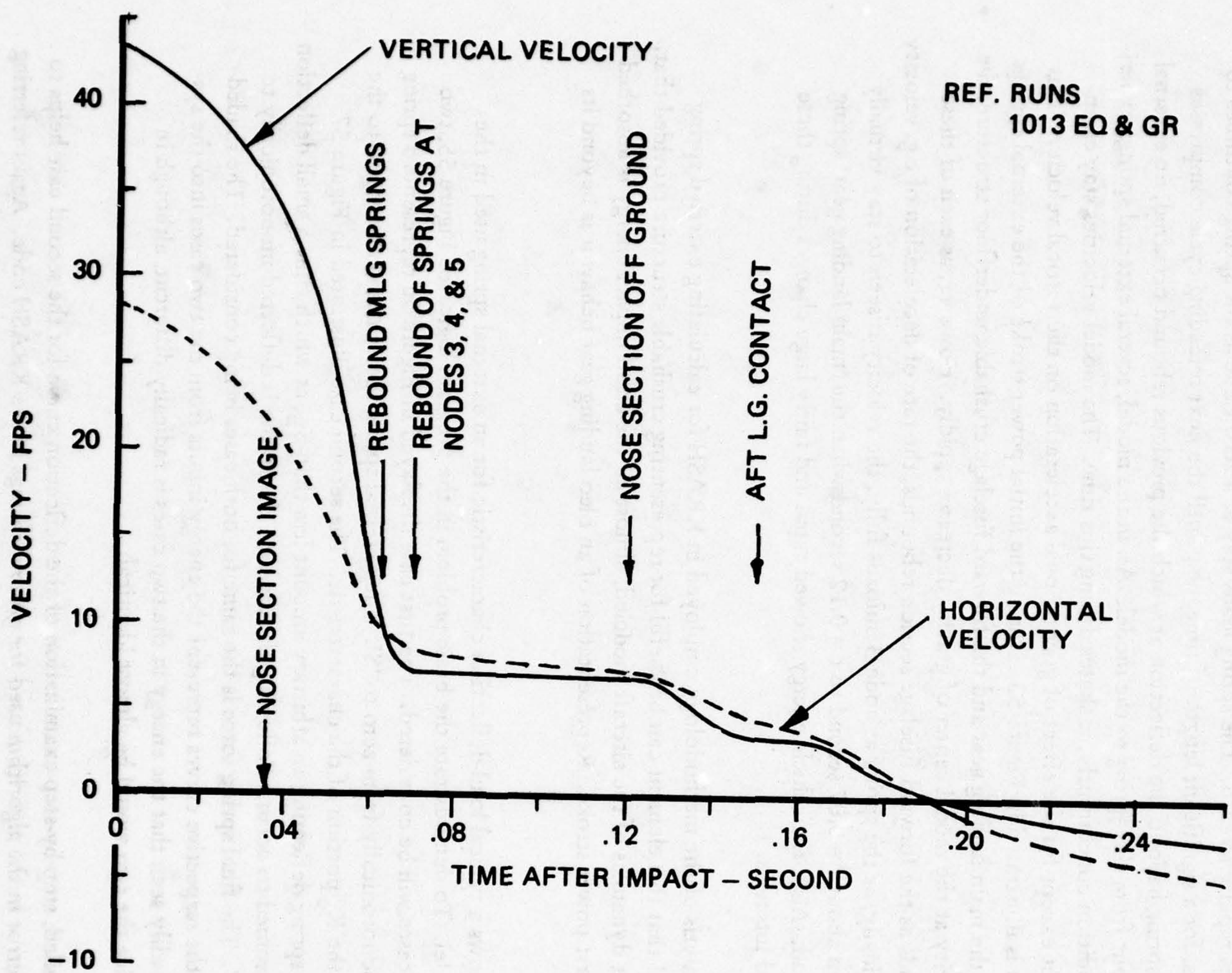

Figure 53. CH-47A Crash Test Simulation Showing Skating Phenomenon and Horizontal Velocity Reversal.

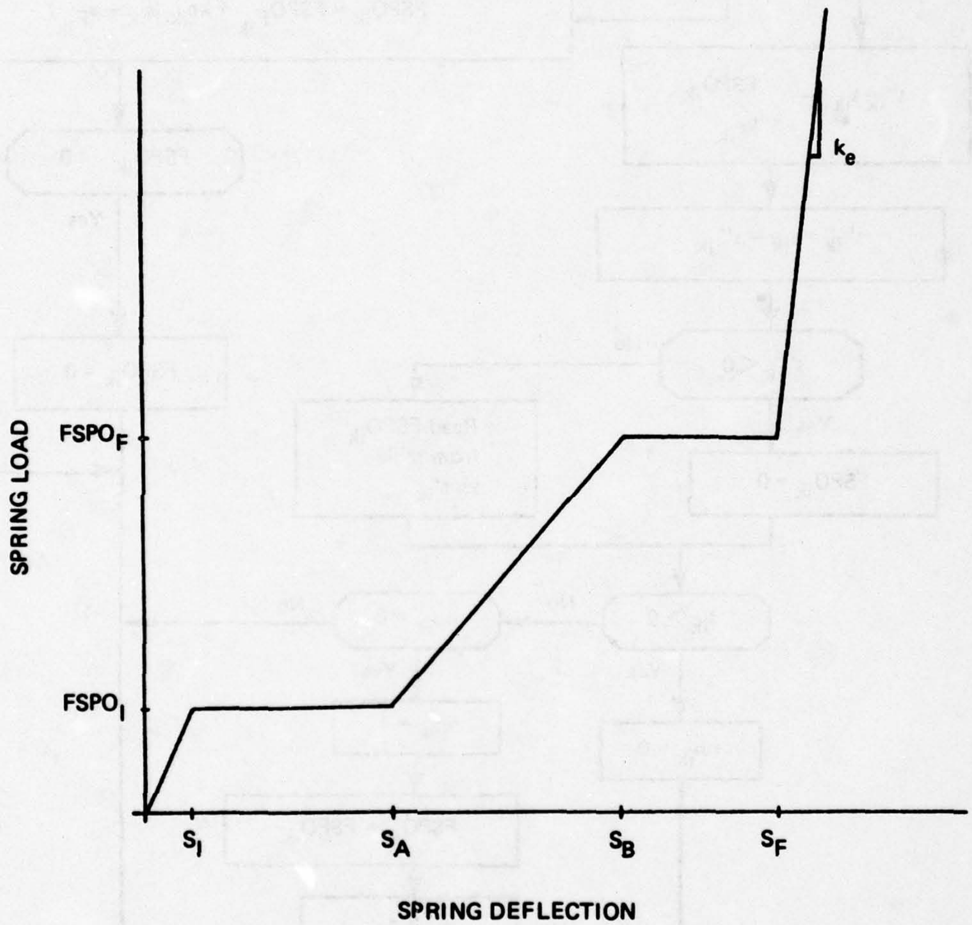

Figure 54. Typical KRASH External Spring Load Stroke Characteristic.

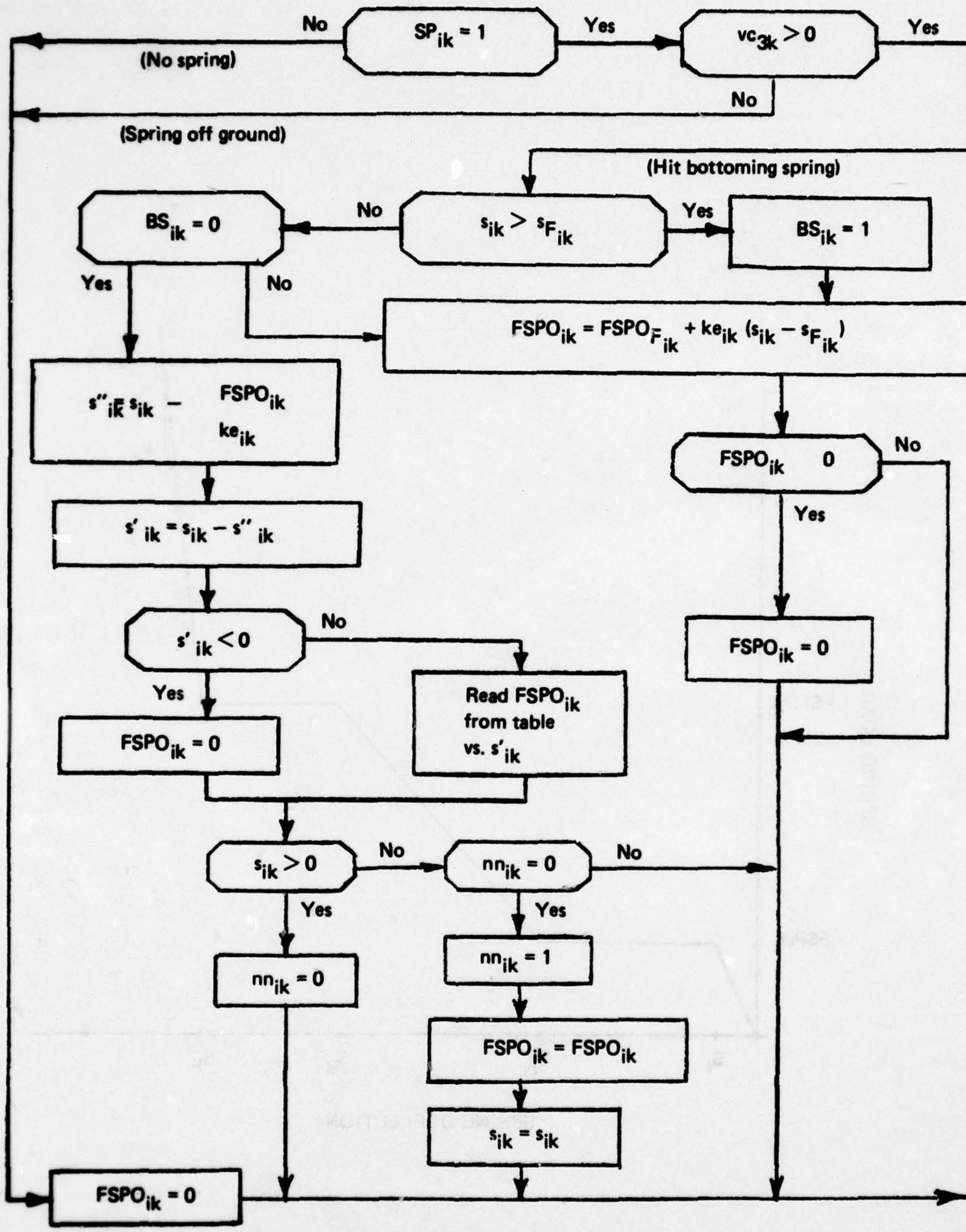

Figure 55. External Spring Load Calculation Flow in KRASH.

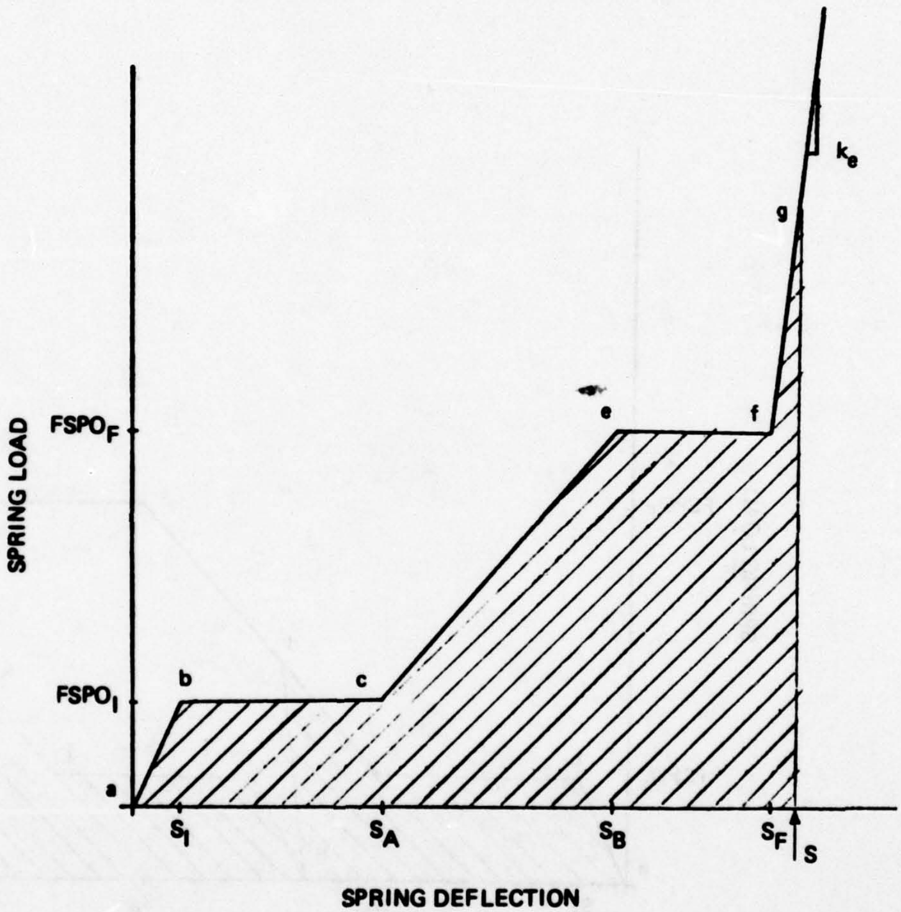

Figure 56. KRASH Program – Energy and Force From Monotomic Deflection of External Spring.

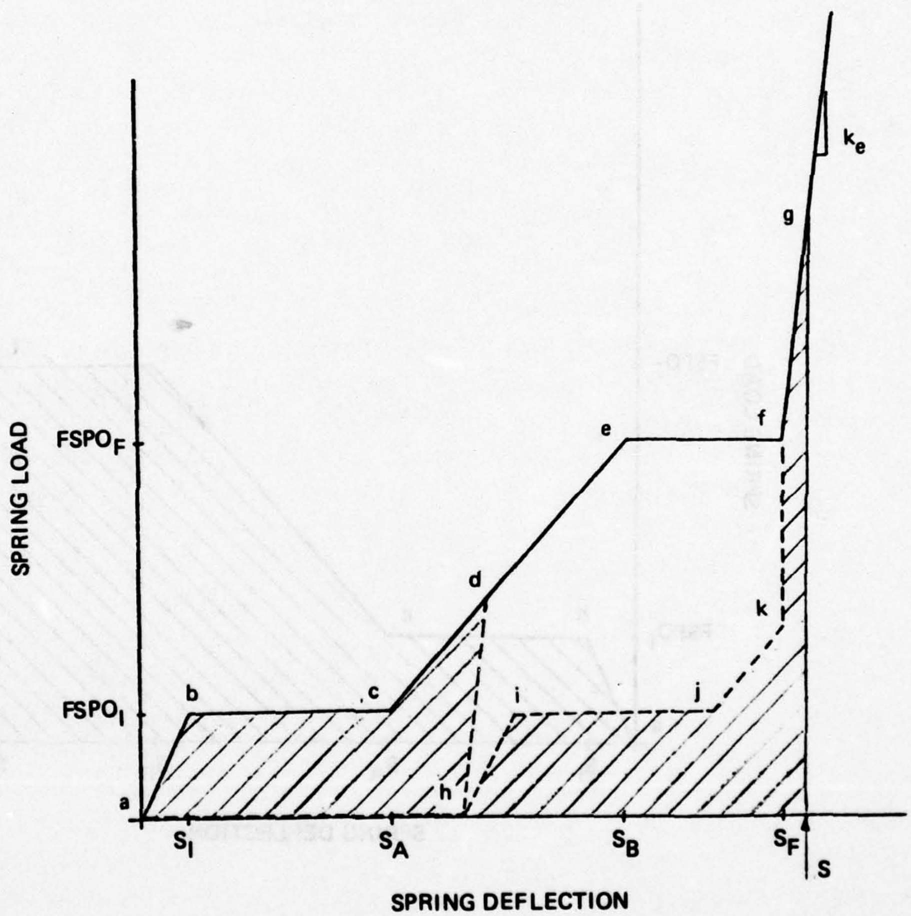

Figure 57. KRASH Program – Effect of a Load Reversal on External Spring Loads and Energy.

Further spring deflection causes loads to be calculated along the original ground spring curve a-b-c-d transposed to a new origin at point 'h'. This is shown by the curve h-i-j-k-f-g. In real frangible structure, reloading should be along a-h-d-e, etc. This results in improper loads and energy being computed. It is also of interest to note that during a rebound prior to the bottoming spring being hit, load increases parallel to the initial shape of the ground spring curve and decreases parallel to the K_e slope. Thus, in the case of multiple rebounds with deflections less than S_F, the loads and energies computed would be a very small fraction of the capability available from the crushable structure.

It is apparent from the above discussion that several corrections have to be incorporated into the external spring load calculation methodology for it to properly represent crushable structure behavior. Representation of oleo strut behavior is a far more complex issue, as velocity squared damping and recoil characteristics have to be considered. Program improvements of this nature, however, were beyond the scope of this effort. The modifications attempted in the modeling of the aircraft to overcome the limitations imposed by these problems are discussed in the next section.

5.2.3 Modified Model

Because of the inability of the KRASH program to represent typical oleo/strut-type aircraft landing gear configurations, it was necessary to use two external springs, masses and beam elements connected to each main landing gear location to approximately represent the estimated oleo strut/tire characteristic under impact conditions. Representation of the tire behavior was provided by the first spring/beam pair, and the second crudely represented the oleo system behavior during initial stroking. The spring and beam pair representing the pneumatic tire permitted a representation of an initial load impulse followed by sudden loss of load (tire bursting). After a further short drop, the second ground spring contacts the ground plane and reintroduces loads through the simulated landing gear beam. This second beam element was used to represent the remaining structural stiffnesses between the ground and the main airframe components. The effective mass of the landing gear was apportioned between the two masses. The external spring properties were adjusted to maintain equivalence in terms of energy absorption over the full landing gear stroke. However, in order to ensure the springs stroking without rebound during the real power stroke, the load-stroke relationship had to be compromised such that the springs are essentially soft. This reduces the magnitude and rate of loads induced into the aircraft during impact. Also, the accelerations obtained at the two masses are not directly meaningful. The analytical data will have to be adjusted by manually recomputing the acceleration at the landing gear location by combining the inertial forces from several masses. It should be recognized that this is only a make-shift idealization of the landing gear and will not provide for accurate simulation of local response.

Secondly, as noted previously the structural failure in the crash test of both aft landing gears at almost the instant of aft gear contact was inexplicable. Because of this abrupt failure, a

sophisticated model of the aft gear was not attempted. In order to represent this failure in the model simulation, it was necessary to arbitrarily reduce axial, torsional, and bending stiffnesses of the elements representing the aft landing gear and to significantly reduce the rupture criteria for these elements.

The above modifications necessitate several changes in the basic model in order to stay within program constraints. The modified model contained 37 mass points, 63 beam elements, and 32 axial and one-sided elements. Six ground springs were used to represent the landing gears with an additional 12 ground springs being used to simulate the frangible underfloor structure.

Figures 58 through 60 are schematics of this modified model. The model mass properties are shown in Table 7.

Several iterations on S-79 were required before the load deflection characteristics of the external springs and beams representing the main landing gears were dynamically acceptable.

5.2.4 Simulation Studies

The model described above required several adjustments, particularly in regard to beam element KR factors and rupture criteria. These adjustments are required as the interaction between the stiffness matrix elements, and the associated KR factor tables depend upon independently derived deflections of a beam. Thus, changes in the rates of load introduction, model geometry, or mechanical relationships in the forces and moments applied to the nodal masses affect the direction in which the beam enters a plastic state. As this situation may result in beam forces being computed in the plastic region for one component while the other components are being computed in the elastic region, incompatible forces and moments are generated. Under these conditions, a negative strain energy may also be computed for the beam. Six additional computer runs were required to arrive at mutually compatible beam element stiffness, stiffness reduction factors, and rupture criteria which minimized these problems. The final run, number 1013JD, provided a reasonably acceptable simulation of the CH-47A impact dynamics in terms of principal impact and external structural rupture sequence when compared with test film analysis data.

A detailed review of the dynamic response data from this simulation indicated that several problems still existed, namely development of an approximately 3-foot-per-second lateral drift velocity, lack of symmetry, and reversal of forward velocity. By this time, a version of KRASH entitled S-79 TEMX incorporating corrected equations of motion (see paragraph 5.2.2) was available. S-79 TEMX had been validated against the cruciform model, Figure 52, and results from Test No. 3 of Reference 3. It was considered possible that a more acceptable simulation may be obtained by using this program. The results from attempts to do so were extremely disappointing. A detail discussion follows.

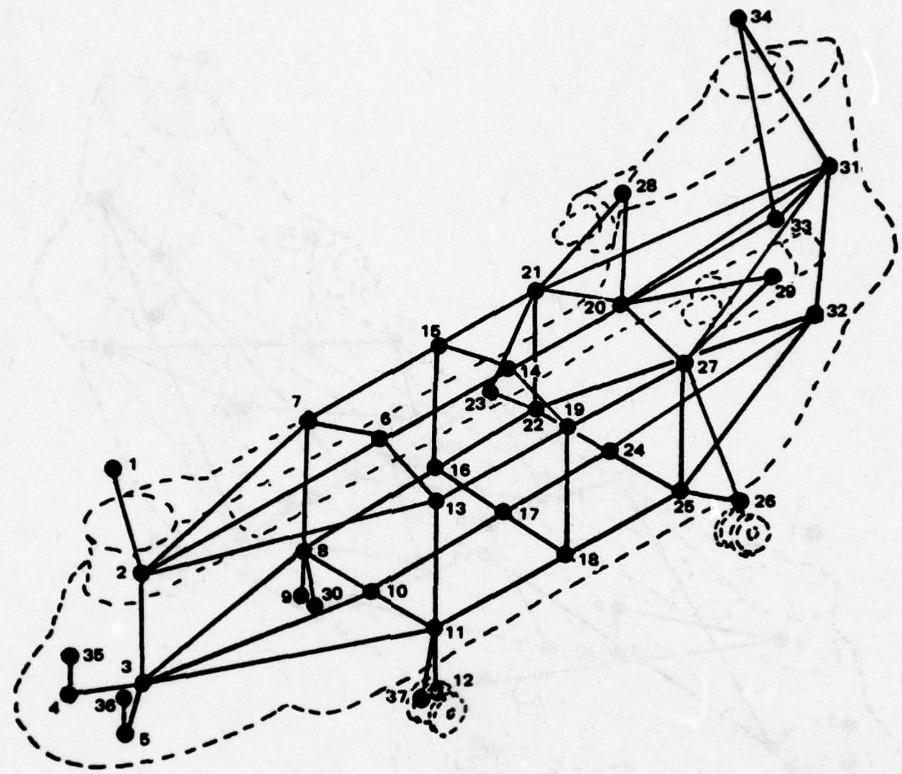

Figure 58. CH-47A Modified Model – Nodal Points, Masses, and Beam Elements.

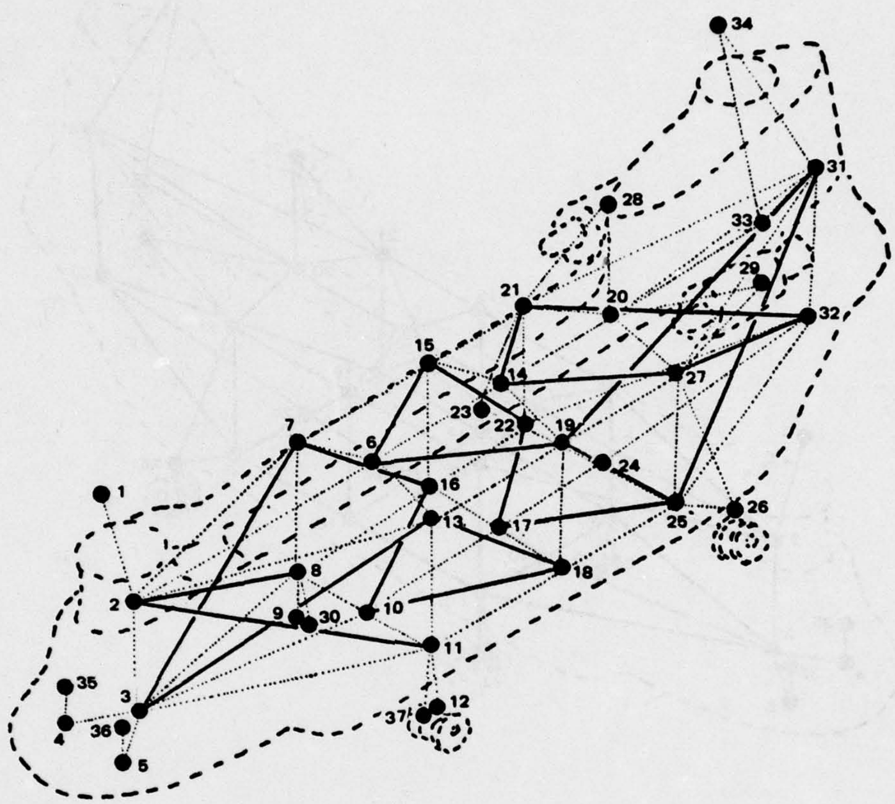

Figure 59. CH-47A Modified Model – One-Sided Elements Representing Skins.

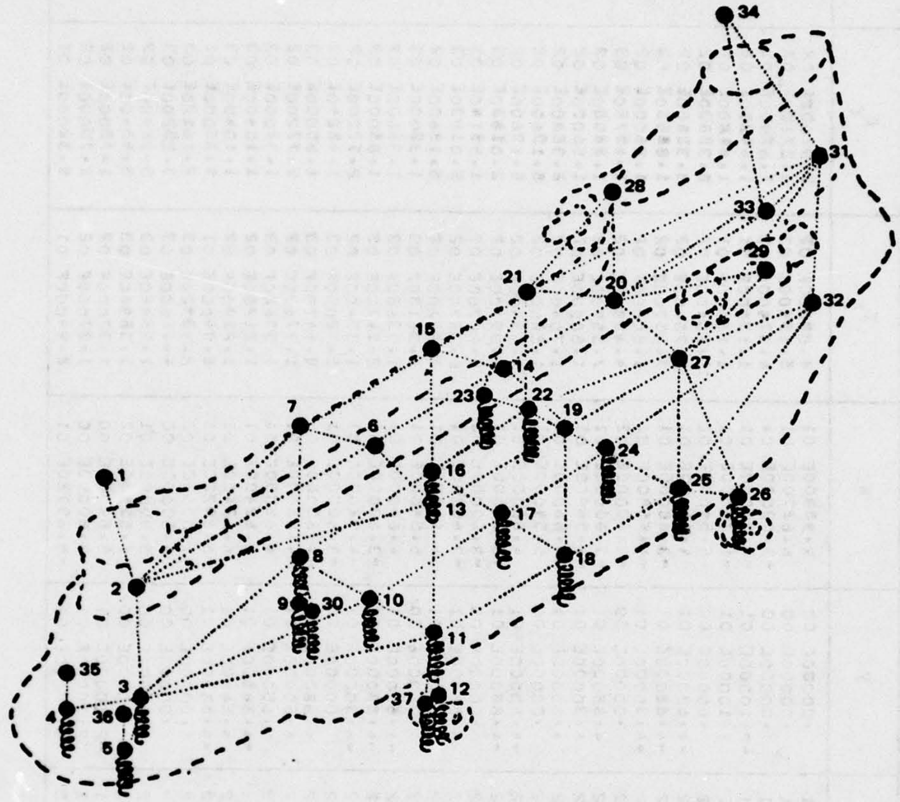

Figure 60. CH-47A Modified Model – External Springs Representing Frangible Structure and Landing Gear.

TABLE 7. MODIFIED CH-47A KRASH MODEL MASS PROPERTIES

Node No.	Weight (lb)	Coordinates (in.)			Moments of Inertia (lb in. sec^2)		
		x	y	z	I_x	I_y	I_z
1	1.21200E 03	8.60000E 01	.00000E 00	9.98800E 01	4.08000E 02	3.97000E 02	7.62000E 02
2	1.71800E 03	9.23400E 01	.00000E 00	6.62700E 01	5.19500E 03	6.27100E 03	6.13400E 03
3	2.47800E 03	9.50000E 01	.00000E 00	-3.00000E 01	6.37900E 03	7.67900E 03	7.82900E 03
4	1.75000E 02	7.51500E 01	-2.10000E 01	-1.70000E 01	1.13000E 01	1.44800E 02	5.00000E 01
5	1.75000E 02	7.51500E 01	2.10000E 01	-1.70000E 01	1.13000E 01	1.44800E 02	5.00000E 01
6	2.18800E 02	2.40000E 02	.00000E 00	5.54000E 01	1.70400E 02	8.38800E 02	9.75600E 02
7	2.18800E 02	2.40000E 02	-4.65000E 01	4.66000E 01	1.70400E 02	8.38800E 02	9.75600E 02
8	1.08150E 03	2.40000E 02	-4.88000E 01	-3.60000E 01	7.35700E 02	1.88580E 03	1.92020E 03
9	1.61000E 02	2.45000E 02	-6.30000E 01	-4.56500E 01	1.50000E 02	1.56000E 02	2.22000E 01
10	1.60100E 03	2.40000E 02	.00000E 00	-3.60000E 01	4.43900E 02	1.45780E 03	1.60610E 03
11	1.10550E 03	2.40000E 02	4.88000E 01	-3.60000E 01	7.35700E 02	1.88580E 03	1.92020E 03
12	1.61000E 02	2.45000E 02	6.30000E 01	-4.56500E 01	1.50000E 02	1.56000E 02	2.22000E 01
13	2.18800E 02	2.40000E 02	4.65000E 01	4.66000E 01	1.70400E 02	8.38800E 02	9.75600E 02
14	2.05550E 02	3.60000E 02	.00000E 00	5.54000E 01	1.58600E 02	5.19600E 02	6.08400E 02
15	1.54400E 02	3.60000E 02	-4.65000E 01	4.66000E 01	1.53600E 02	5.19600E 02	6.08400E 02
16	1.48940E 03	3.60000E 02	-4.88000E 01	-3.60000E 01	6.39700E 02	2.01830E 03	1.74130E 03
17	1.88240E 03	3.60000E 02	.00000E 00	-3.60000E 01	9.10700E 02	1.99140E 03	2.02980E 03
18	1.43750E 03	3.60000E 02	4.88000E 01	-3.60000E 01	6.39700E 02	2.01830E 03	1.74130E 03
19	1.54400E 02	3.60000E 02	4.65000E 01	4.66000E 01	1.53600E 02	5.19600E 02	6.08400E 02
20	5.74750E 02	4.82000E 02	.00000E 00	5.54000E 01	1.36180E 03	1.38000E 03	1.61880E 03
21	3.03900E 02	4.82000E 02	-4.65000E 01	4.66000E 01	1.33680E 03	1.38000E 03	1.61880E 03
22	3.70000E 02	4.82000E 02	-4.88000E 01	-3.60000E 01	2.14700E 03	1.85000E 03	2.09050E 03
23	1.96000E 02	5.09000E 02	-6.30000E 01	-4.08000E 01	1.37600E 02	2.77200E 02	1.83600E 02
24	1.30660E 03	4.82000E 02	.00000E 00	-3.60000E 01	1.72050E 03	1.48240E 03	1.67510E 03
25	3.70000E 02	4.82000E 02	4.88000E 01	-3.60000E 01	2.14700E 03	1.85000E 03	2.09050E 03
26	1.96000E 02	5.09000E 02	6.30000E 01	-4.08000E 01	1.37600E 02	2.77200E 02	1.83600E 02
27	3.03900E 02	4.82000E 02	4.65000E 01	4.66000E 01	1.33680E 03	1.38000E 03	1.61880E 03
28	7.73000E 02	5.04920E 02	-4.84500E 01	6.62400E 01	1.21200E 02	1.10400E 03	1.10400E 03
29	7.73000E 02	5.04920E 02	4.84500E 01	6.62400E 01	1.21200E 02	1.10400E 03	1.10400E 03
30	9.70000E 01	2.40000E 02	-4.88000E 01	-5.69720E 01	8.94000E 01	9.32000E 01	1.34000E 01
31	3.15000E 02	5.76000E 02	.00000E 00	1.00000E 02	2.93520E 03	2.16120E 03	2.16120E 03
32	4.74000E 02	5.76000E 02	.00000E 00	8.50000E 00	4.41600E 03	3.25200E 03	3.25200E 03
33	1.19200E 03	5.58100E 02	.00000E 00	5.95000E 01	1.38960E 03	5.96400E 02	2.05200E 02
34	1.39600E 03	5.52620E 02	.00000E 00	1.55530E 02	1.38960E 03	5.96400E 02	6.53000E 01
35	2.12000E 02	7.51500E 01	-2.10000E 01	5.50000E 00	1.37000E 02	1.75000E 02	6.07000E 01
36	2.12000E 02	7.51500E 01	2.10000E 01	5.50000E 00	1.37000E 02	1.75000E 02	6.07000E 01
37	9.70000E 01	2.40000E 02	4.88000E 01	-5.69720E 01	8.94000E 01	9.32000E 01	1.34000E 01
Model Properties:							
	0.2501E05	0.3236E03	-0.554E-01	0.1105E02	0.3307E06	0.2127E07	0.1960E07

The CH-47A (KRASH) model, Figure 58, was simulated on S-79 TEMX for the test impact conditions. The simulation results indicated a severe energy 'blow-up' and instability of the solution process after about 0.06 second. The vehicle total energy increased almost exponentially and had grown by several orders of magnitude at 0.2 second. A detailed analysis indicated a divergent lateral oscillation of mass 1. The divergence was so rapid that this mass literally rolled over into the ground, developing extremely large kinetic as well as negative potential energies. This instability was seen to be affecting the responses of masses 2 and 3 as well. Also, the external springs at 3, 4, and 5 stroked well beyond their limits, indicating a total breakdown in the solution process. In an attempt to determine possible sources for this problem, several additional computer runs were made while varying the following parameters:

- Integration error controls
- Minimum time step for integration
- Structural damping

None of the changes had any noticeable effect on either the onset or severity of the divergence. Also, a run with mass 1 effectively decoupled from the model showed that masses 2 and 3 exhibited the same type of divergence. Finally, to determine whether the problem was in any way associated with the yielding of major structural elements, the KR tables were eliminated from the input and the model simulated on both S-7900 and S-79 TEMX. The raw data for several significant parameters obtained from these two runs are shown in Figures 61 through 66.

A detailed review of the data shown led to the following conclusions:

- No significant difference exists between the two simulations up to 0.04 to 0.05 second after impact.

- The model when simulated on S-79 TEMX exhibits a high degree of instability, invalidating the results beyond about 0.06 second or 1,000 iterations.

- This divergence does not appear to be directly related to model structural characteristics including effects of plasticity and damping, element ruptures, external spring characteristics, or user-specified integration control data.

- Based on the above, it was concluded that S-79 TEMX will not permit an acceptable simulation of the crash impact characteristics of the CH-47A KRASH model.

It was, therefore, decided that the dynamic response of the model obtained from S-7900 simulation, run 1013JD, shall be correlated with the CH-47A crash test data. The details of these correlation studies are given in the next section.

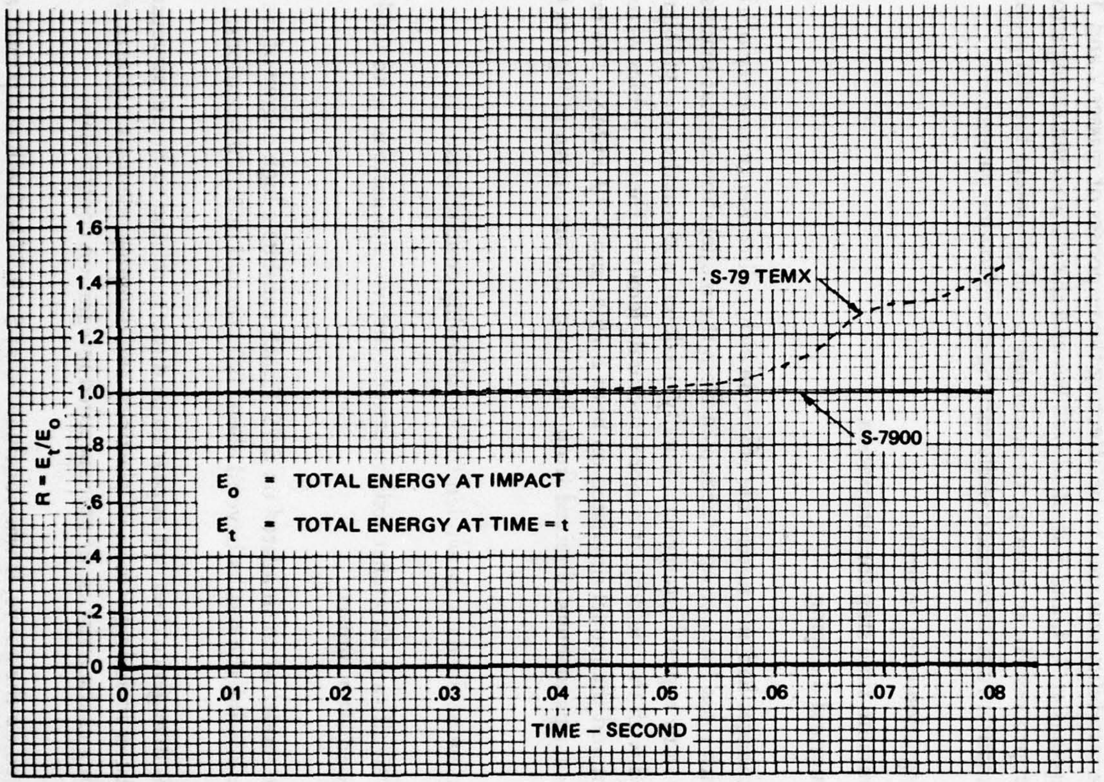

Figure 61. Model Total Energy Divergence, S-79 TEMX Simulation.

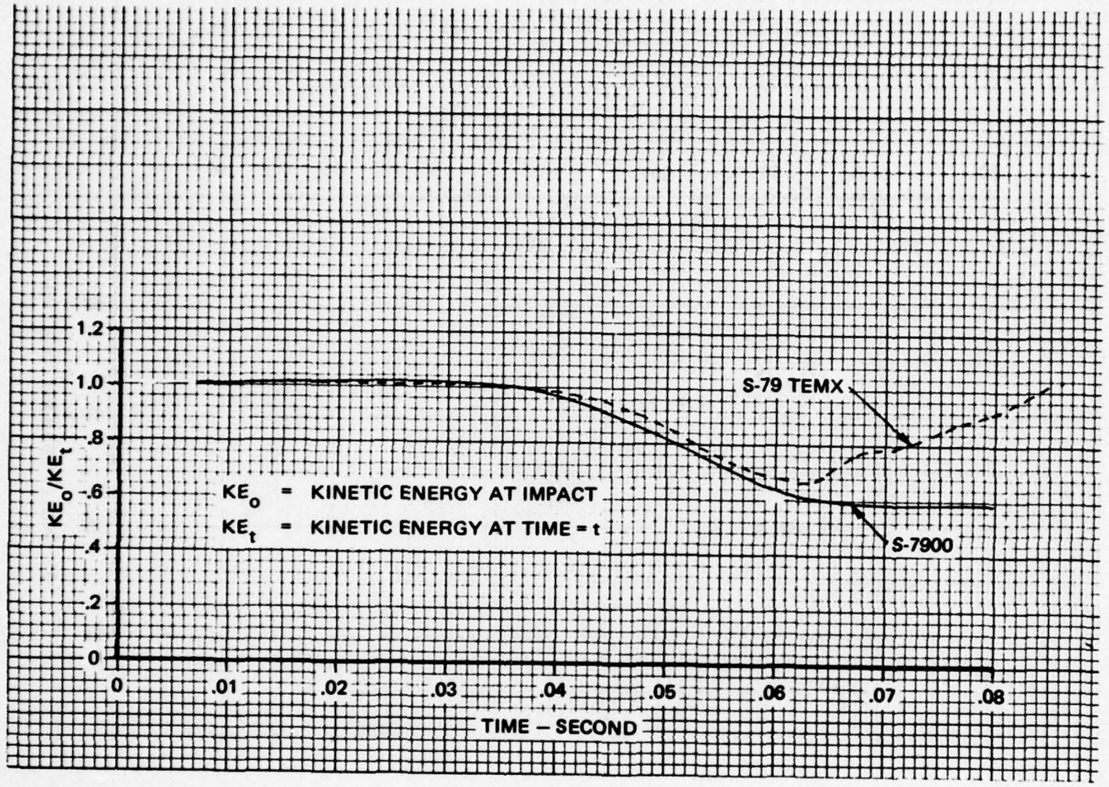

Figure 62. Model Kinetic Energy Divergence, S-79 TEMX Simulation.

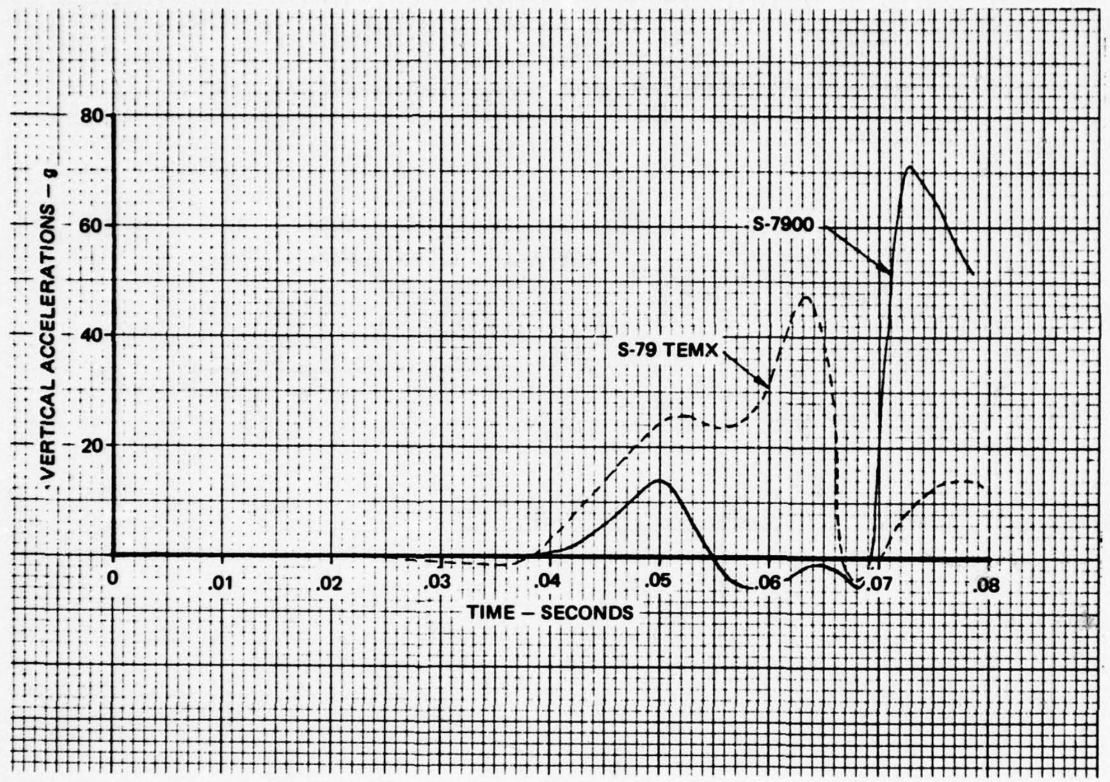

Figure 63. Model Response at F.S. 240, Node 10, S-7900.

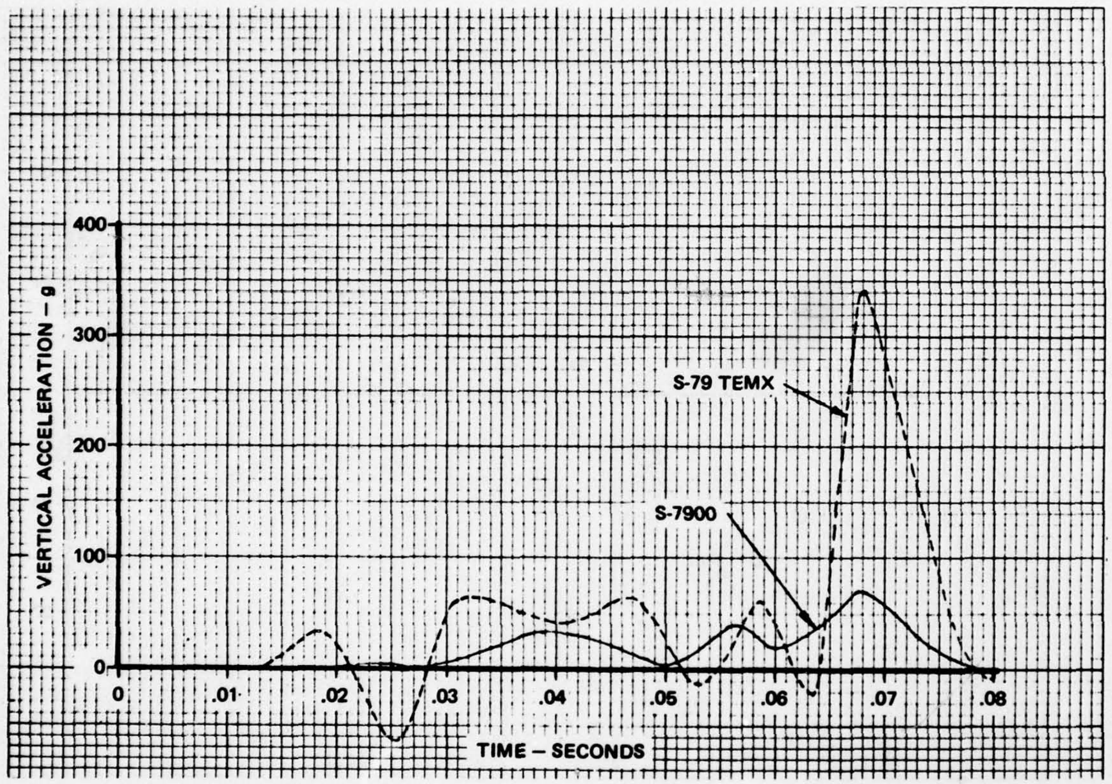

Figure 64. Model Response at Main Landing Gear, Node 12, S-79 TEMX Vs S-7900.

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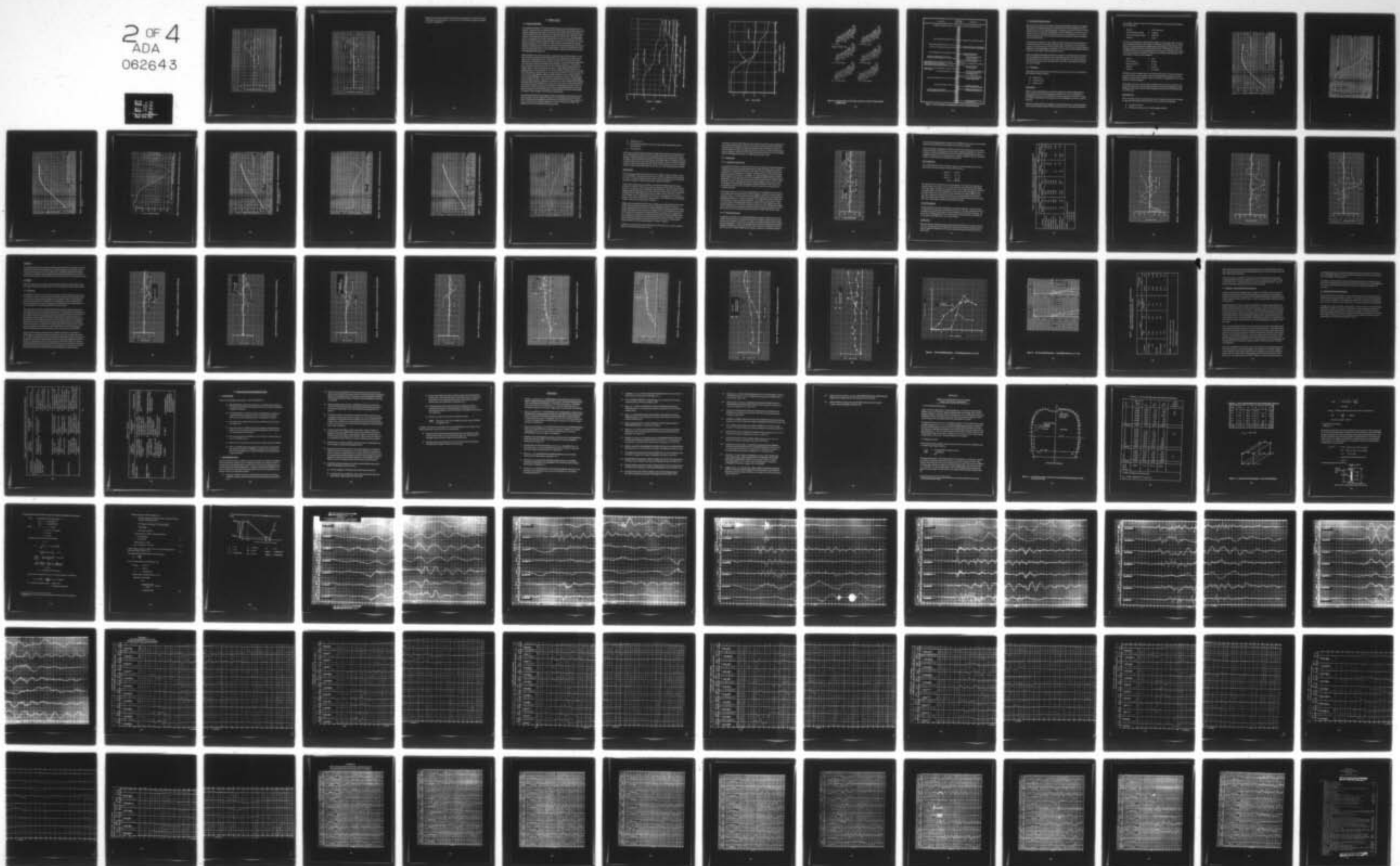

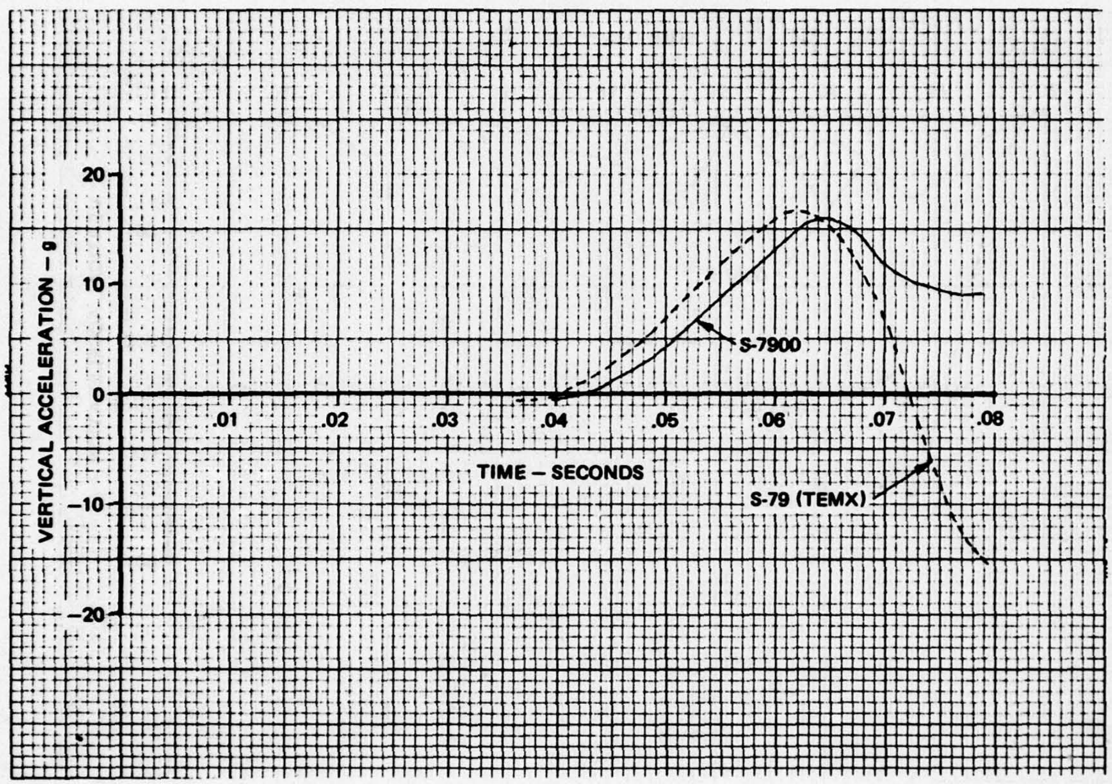

Figure 65. Model Response at F.S. 360, Node 17, S-79 TEMX Vs S-7900.

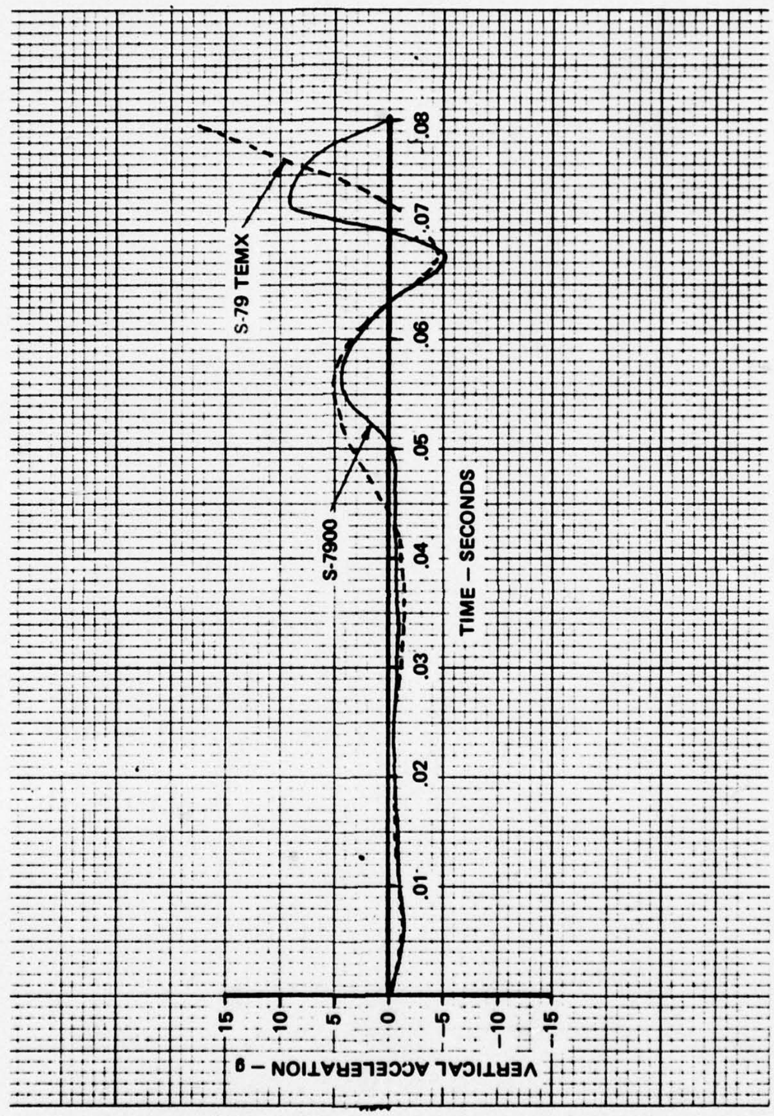

Figure 66. Model Response at Right Engine, Node 28, S-79 TEMX Versus S-7900.

A listing of the computer program S-7900 is included in Appendix E. The input data for run 1013JD and output results at time = 0 and at time = 0.104 second after impact are available for reference in Appendix F.

6.0 CORRELATIONS

6.1 OVERALL RESPONSE

The predicted total energy of the CH-47A KRASH model is shown plotted against time in Figure 67. Also shown are the contributions from vehicle kinetic and potential energy as well as strain, damping, and crush energies. The change in total energy over the solution time of 0.180 second is less than 4%. This represents over 4,000 iterations and compares well with a change of 7.2% obtained during the pretest simulation (see Section 3.4). The largest single source of energy decay is from crush elements which account for approximately 75% of the decay in the vehicle kinetic and potential energy over 0.15 second. A time history of the predicted c.g. velocities is shown in Figure 68. These velocities are obtained in the computer program by dividing the sum of linear momentums in each translational direction by the total mass and, as such, they represent only an approximation. Also, as the vehicle kinetic energy shown includes translational, rotational, and oscillatory contributions, these data cannot be correlated against film analysis data.

Figure 69 illustrates the model connectivity at progressive stages of the simulation. For purposes of clarity, the sketches include beam elements only, and ruptures are indicated by removal of the corresponding element. Further, no attempt has been made to show relative displacements of nodal points or ground contact sequence. An event summary comparing the test article and the math model simulation data is furnished in Figure 70. This provides a gross comparison of the dynamic response in terms of times at ground spring contacts and element ruptures. Several comments are necessary to supply background information on possible inaccuracies in indicated times. For the test article, the indicated times are from high-speed film analysis. In general, these are very close to actual times but inaccuracies exist. Because of camera angle, lighting conditions and film resolution, it was not always possible to view the bottom fuselage area to determine the precise instant of contact. This necessitated several viewings of the film. It was noticed that individual frames in the film warped slightly during successive projections, resulting in a loss of precision in later dimensional measurements. The indicated times of local failures are not exact for similar reasons. On the other hand, the times shown for element ruptures in the simulation are exactly the same as those in the computer printout. However, as ground contact times are not specifically printed out, the times shown correspond to that of the first printout at which deflection of a given external spring is indicated or, where possible, obtained by close approximation.

A comparison of the data shown in Figure 70 with corresponding data from the pretest simulation run Figure 51 shows a significant improvement in the dynamic characteristics of the model. The predictions regarding sequential occurrence of both ground contacts and primary structural failures are in much closer agreement with crash test data and are within a few milliseconds of the times established from crash test data.

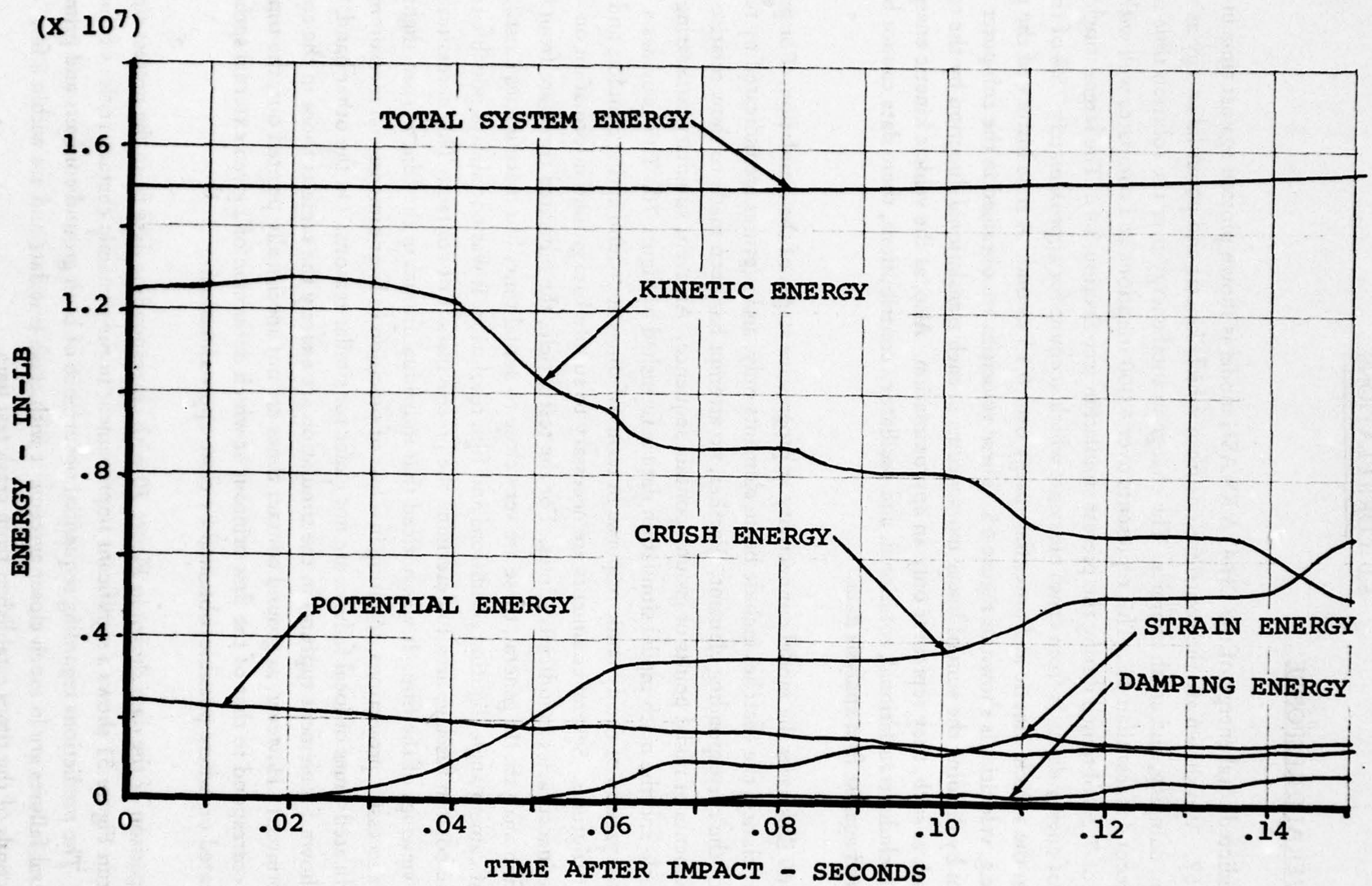

Figure 67. Energy Distributions of CH-47A Crashworthiness Modified Model .

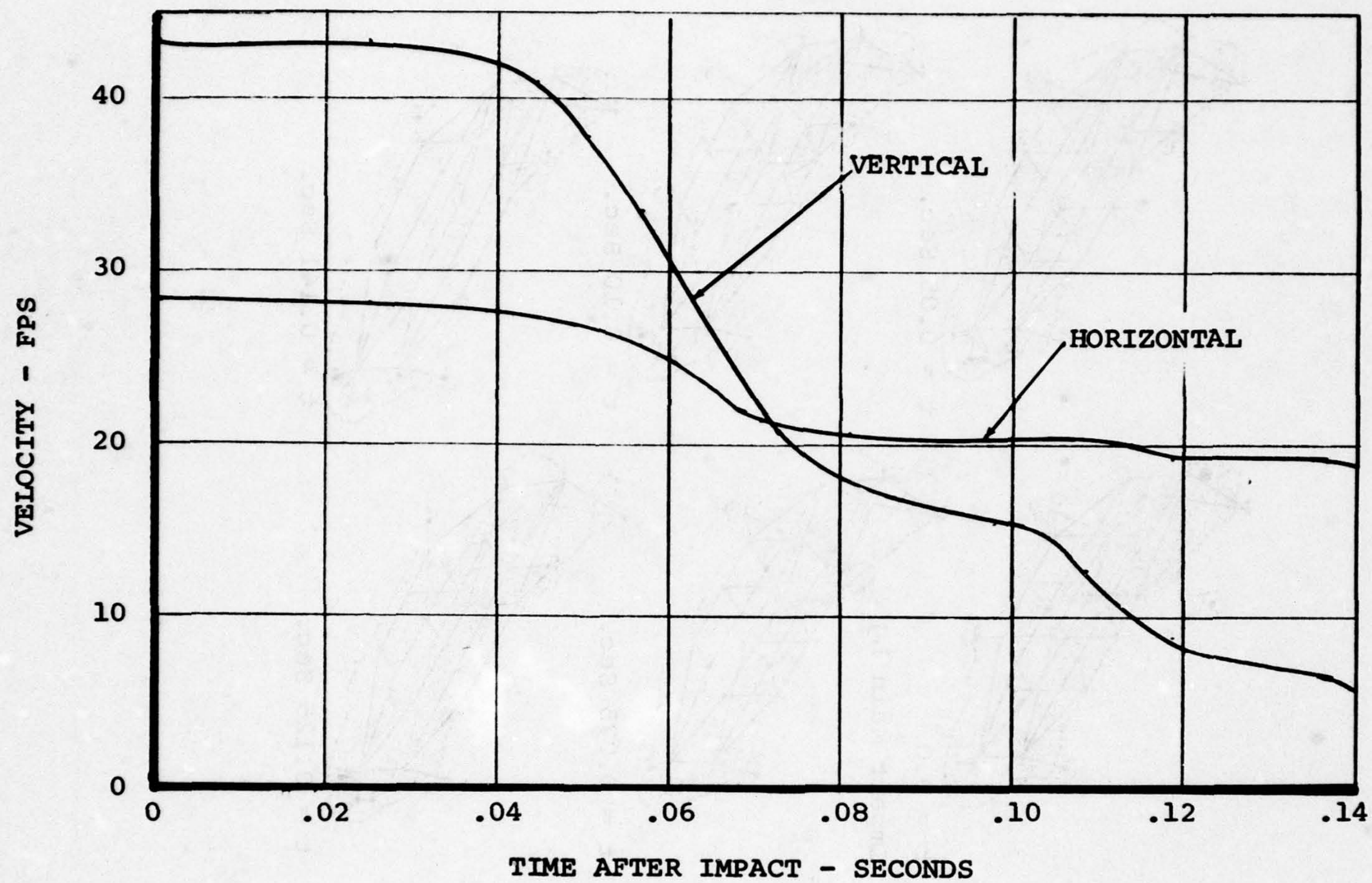

Figure 68. Predicted Velocities at Model C.G.

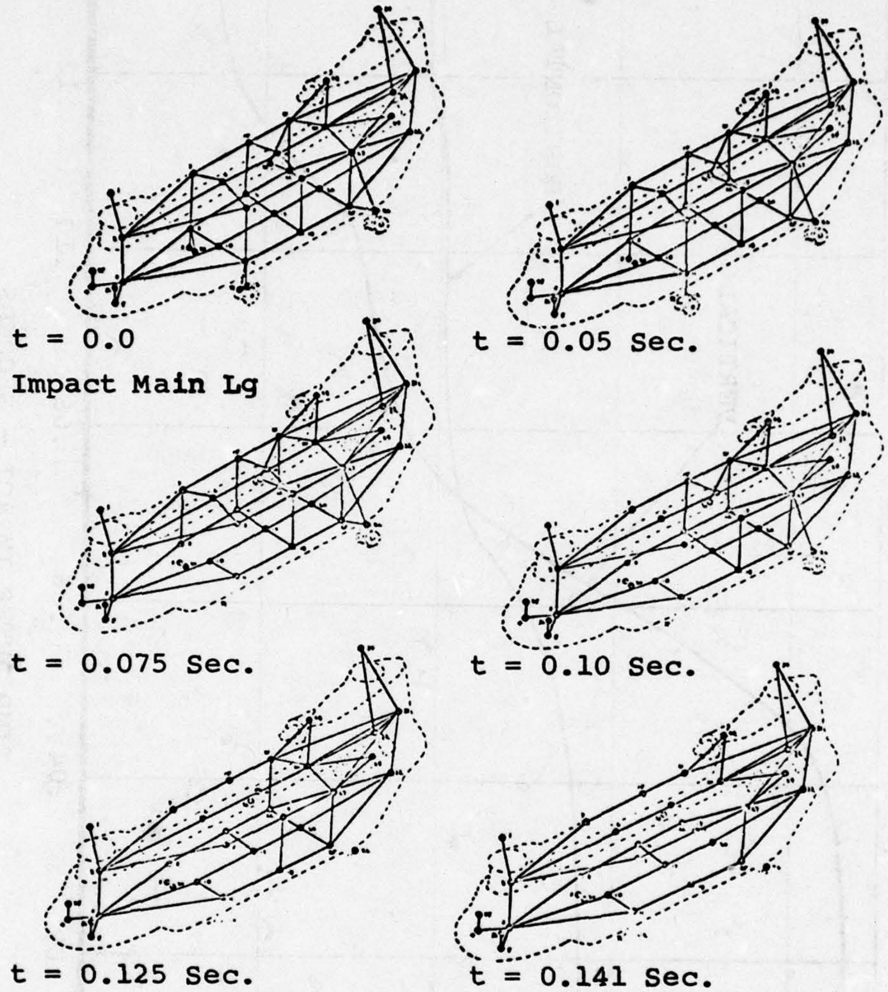

Figure 69. Progressive Decay of Structural Connectivity of CH-47A Crashworthiness Modified Model.

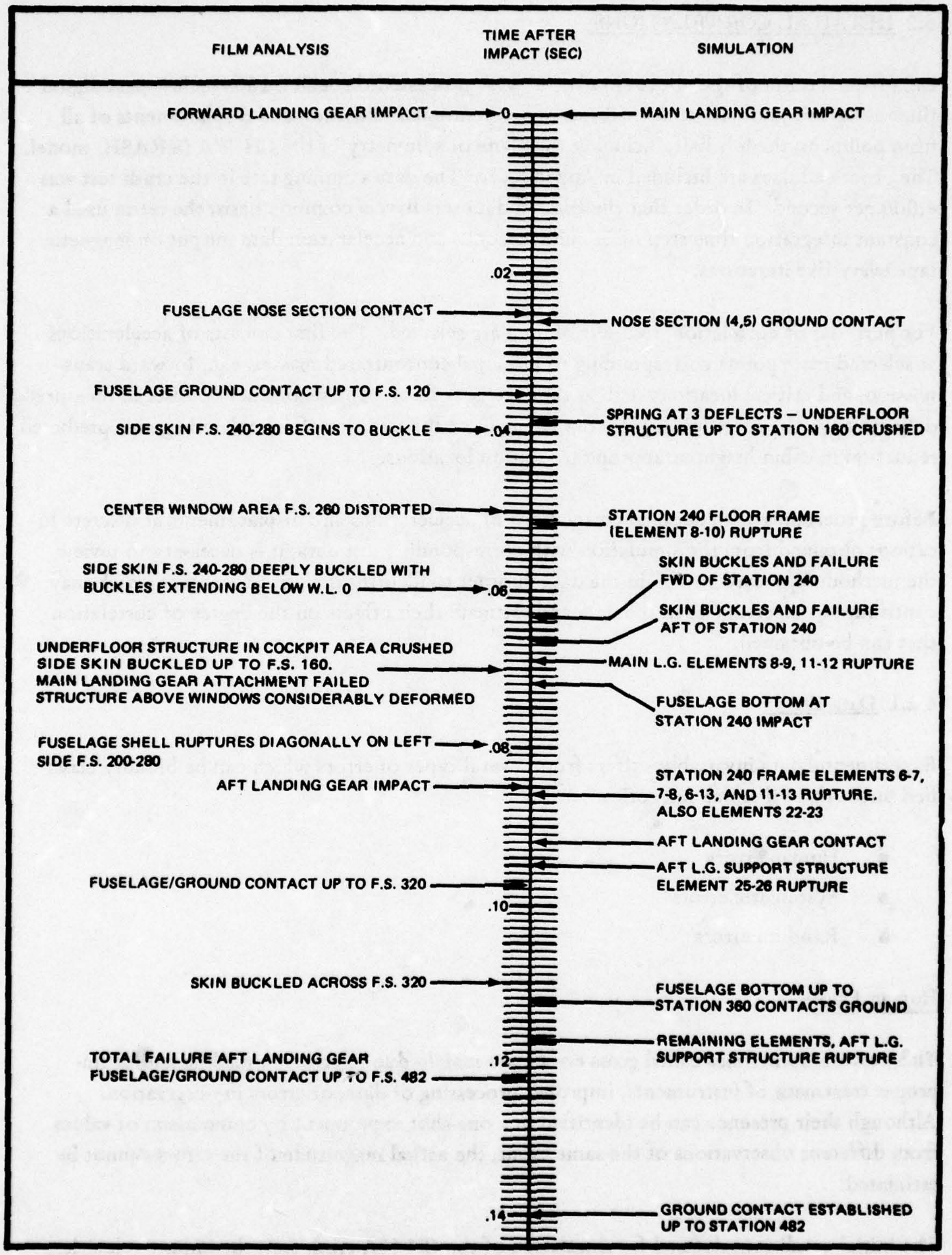

Figure 70. Event Chronology of Modified Model of CH-47A KRASH Simulation.

6.2 DETAILED CORRELATIONS

Data from a rerun of the above simulation were processed through a 100-Hz, low-pass digital filter as before to obtain time histories of accelerations, velocities, and displacements of all mass points on the left half, including the plane of symmetry of the CH-47A (KRASH) model. The processed data are included in Appendix D. The data sampling rate in the crash test was 4,000 per second. In order that the filtered data sets have a common basis, the rerun used a constant integration time step of 50 microseconds and acceleration data output on magnetic tape every five iterations.

For purposes of correlation, two sets of data are selected. The first consists of accelerations at selected mass points corresponding to principal concentrated masses, e.g., forward transmission, and critical locations such as the crew seat floor. The second set consists of measured deflections in the cargo/passenger compartment of the test aircraft correlated against predicted reduction in cabin height at appropriate station locations.

Before proceeding with detailed correlations of accelerations and displacements at discrete locations obtained from the simulation with corresponding test data, it is necessary to review the methodology used to obtain the data in order to identify the various sources which may contribute to inaccuracies in the data and estimate their effects on the degree of correlation that can be obtained.

6.2.1 Data Errors

Experimental data invariably suffers from several types of errors which can be broadly classified under three distinct categories:

- Human errors
- Systematic errors
- Random errors

Human Errors

These errors, sometimes called gross errors, are mainly due to errors in reading and/or improper treatment of instruments, improper processing of data, or errors in observation. Although their presence can be identified in a one-shot experiment by comparison of values from different observations of the same event, the actual magnitude of the errors cannot be estimated.

The initial conditions defined for simulation of the CH-47A crash test, the impact velocities, and the aircraft attitude at impact suffer from this type of error. Three sets of observations

were available. The first consisted of the following estimate from analysis of radar altimeter data by NASA/LRC:

Attitude	=	6-1/2° nose down
Vertical velocity at impact	=	43.82 fps
Horizontal velocity at impact	=	28.307 fps
Resultant	=	52 fps

The next set was obtained by a frame-by-frame analysis of motion picture data. The coordinates of eight discrete points on the airplane in each frame were carefully measured. These data were then statically analyzed using least-squares methodology to obtain a polynomial relating the displacement of each of these points with time. The displacement curves were then differentiated to obtain corresponding velocity time histories. Examples of this analysis for two points are shown in Figures 71 through 78. An analysis of these data yield the following impact conditions at the landing gear:

Attitude	=	8.42°
Vertical velocity	=	44.5 fps
Horizontal velocity	=	27.7 fps
Resultant	=	52.42 fps
Pitch rate	=	0.15 rad/sec

The third set which was finally used for the simulation and is shown in Table 6 was obtained as a result of motion synthesis studies carried out at NASA/LRC and represents their best estimate of the true impact conditions. These were defined to be applicable to the c.g. of the aircraft for simulation purposes.

The probable error of up to 2 fps in impact conditions may cause errors up to 10% in computed mass accelerations. Also, as the precise instant of contact was established from main landing gear accelerometer data, the phase relationship between the test and analytical data may not be exact.

Systematic Errors

These errors arise mostly from instrumentation sources. The primary errors in the accelerometer data obtained during the CH-47A crash test can be ascribed to the following:

- Linearity of response
- Modification of response due to local installation stiffness

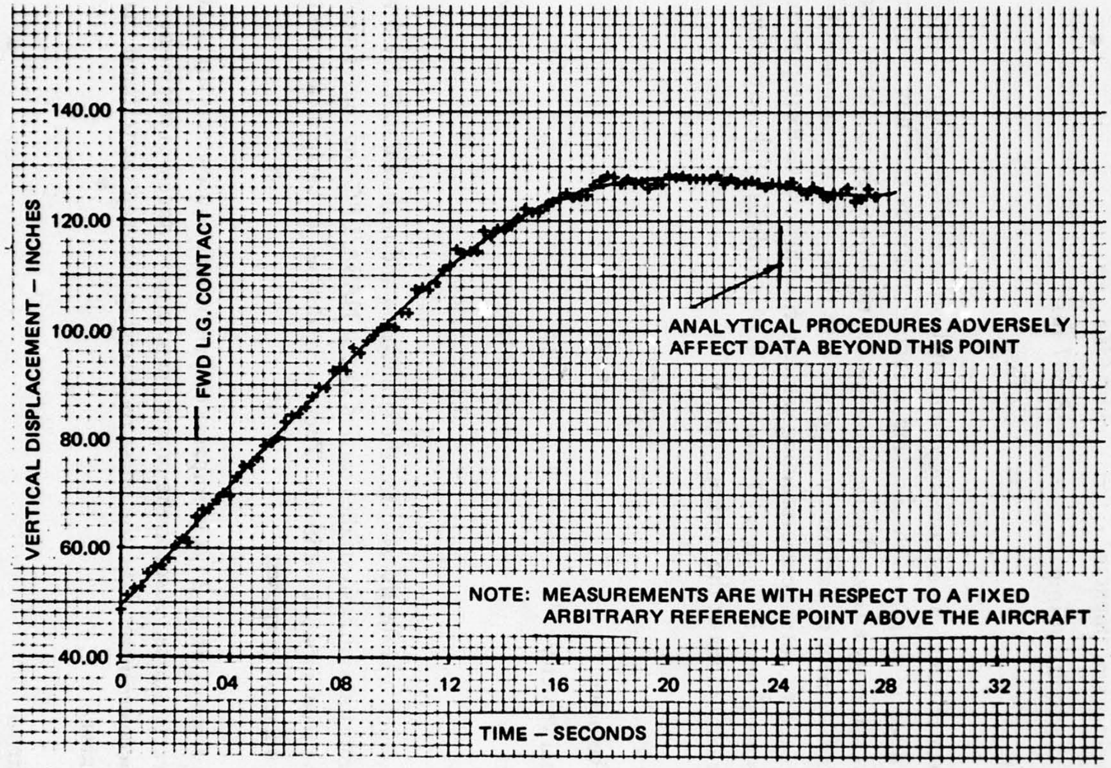

Figure 71. CH-47A Crash Test Film Analysis – Vertical Displacement Time History at F.S. 320, W.L. 0.0.

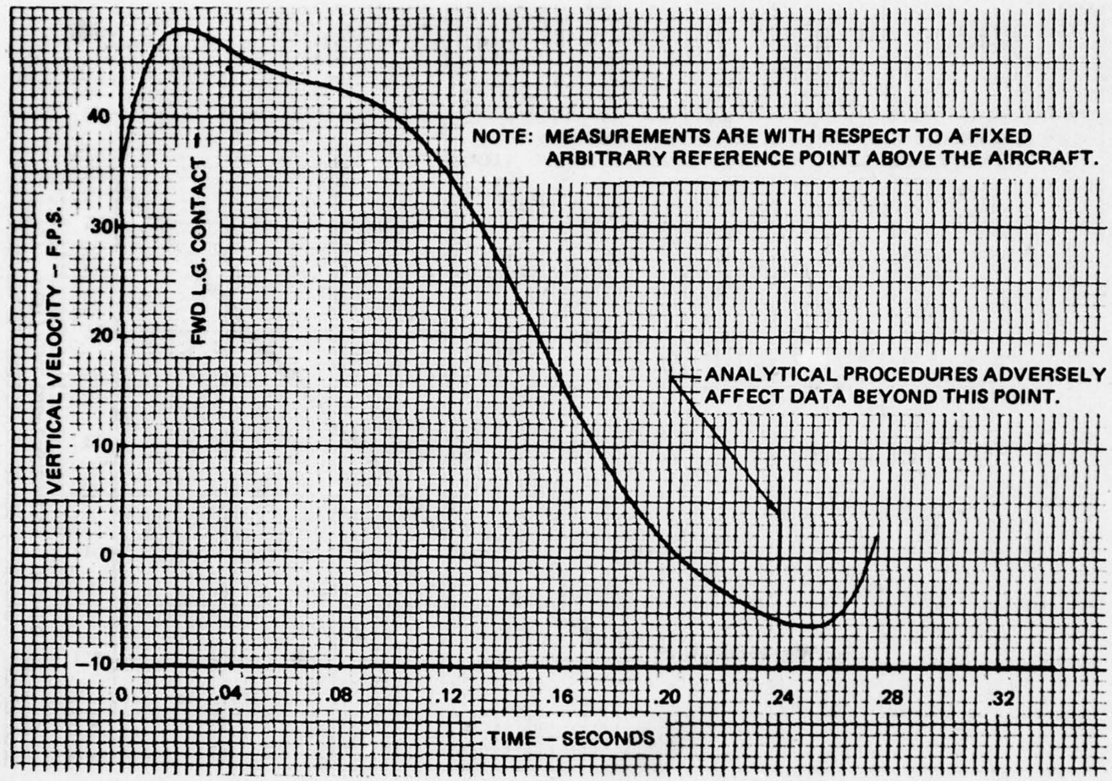

Figure 72. CH-47A Crash Test Film Analysis – Derived Vertical Velocities at F.S. 320, W.L. 0.0.

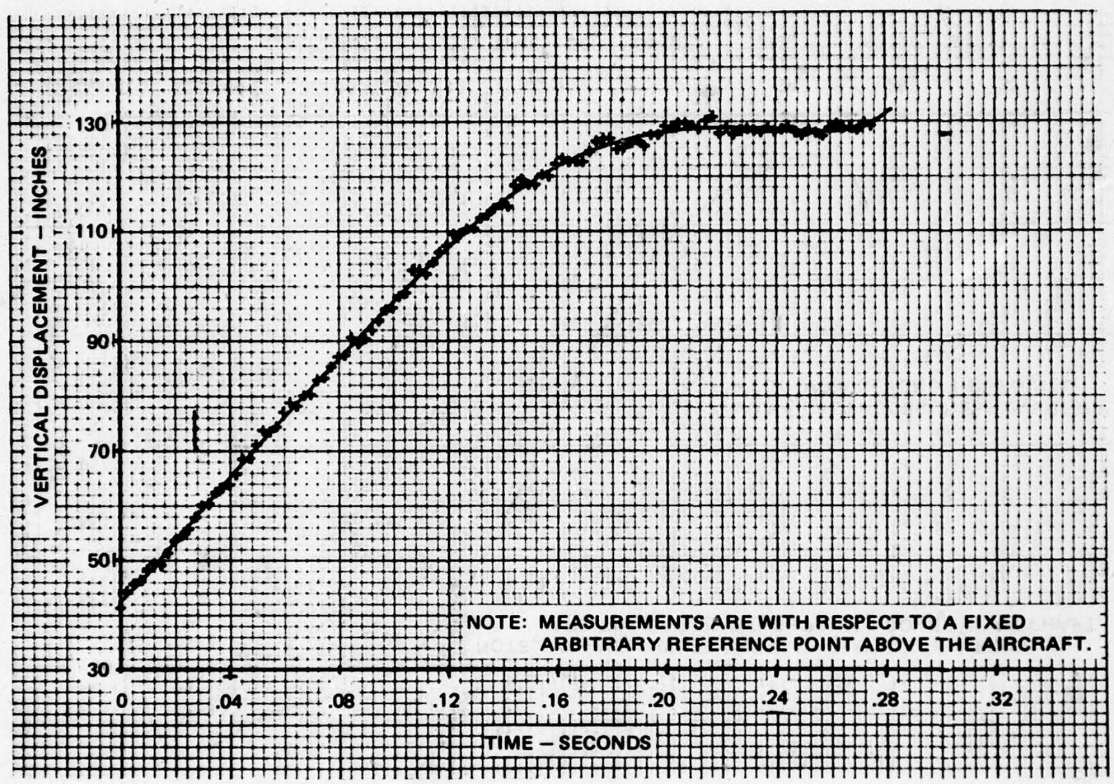

Figure 73. CH-47A Crash Test Film Analysis – Vertical Displacement Time History at F.S. 360, W.L. 0.0.

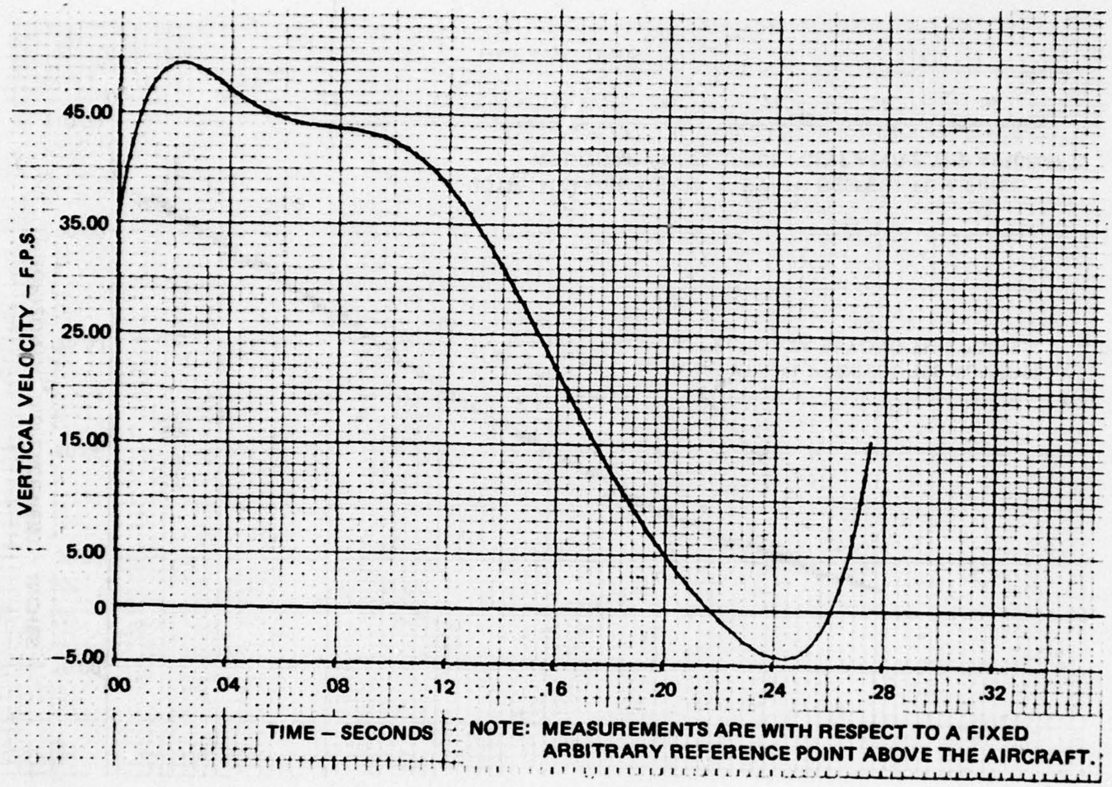

Figure 74. CH-47A Crash Test Film Analysis – Derived Vertical Velocities at F.S. 360, W.L. 0.0.

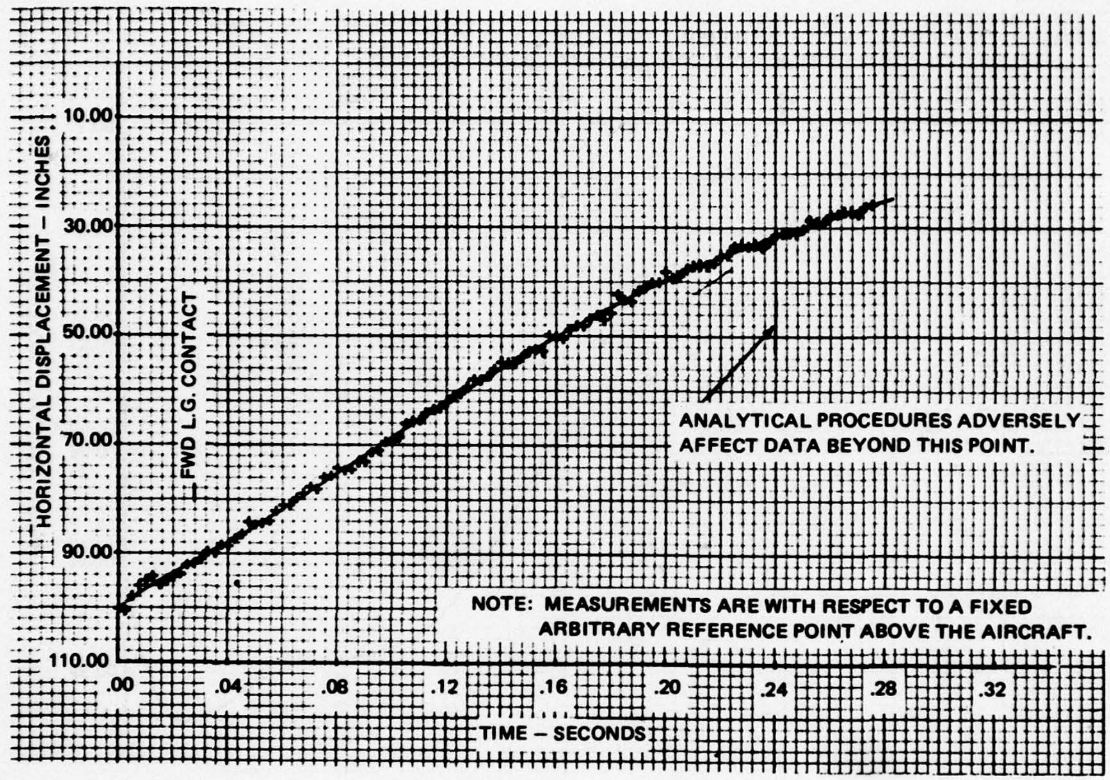

Figure 75. CH-47A Crash Test Film Analysis – Horizontal Displacement Time History at F.S. 320, W.L. 0.0.

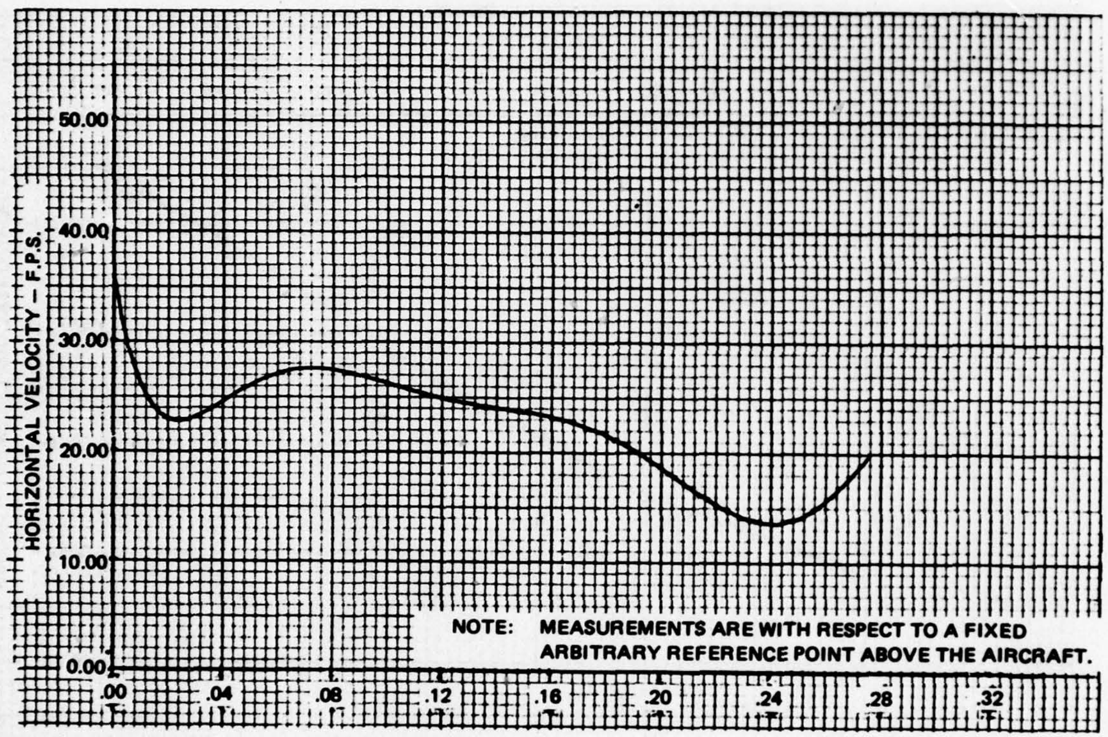

Figure 76. CH-47A Crash Test Film Analysis – Derived Horizontal Velocities at F.S. 320, W. L. 0.0.

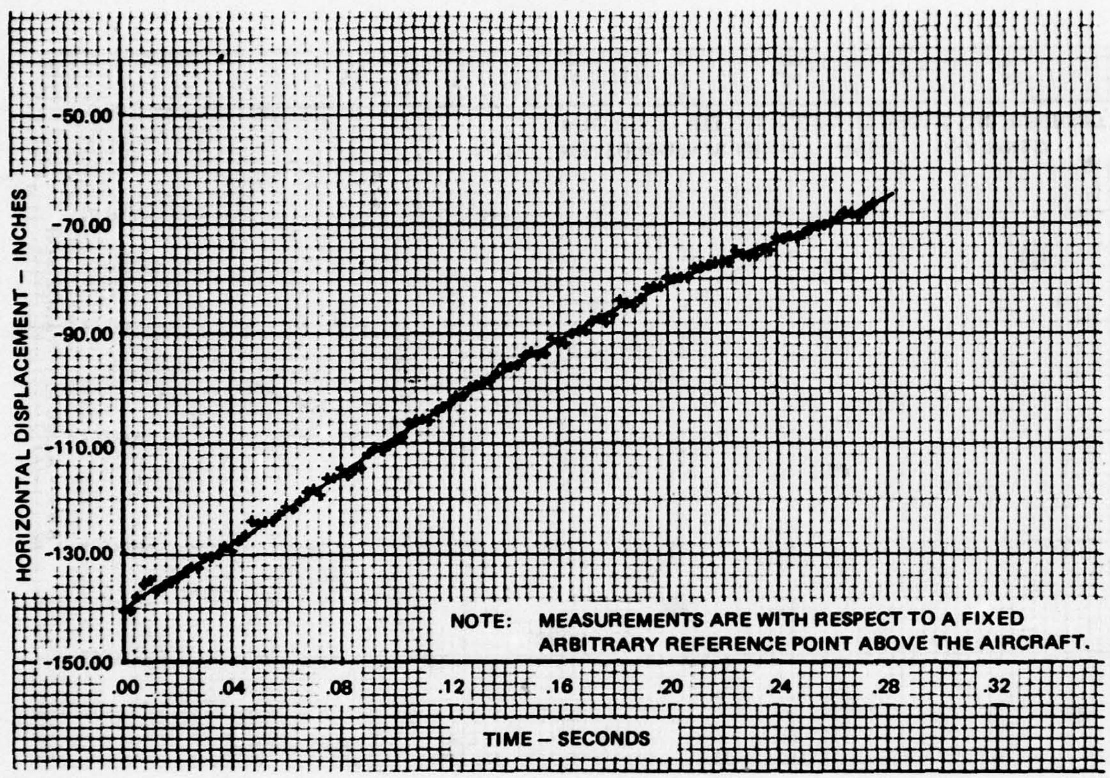

Figure 77. CH-47A Crash Test Film Analysis – Horizontal Displacement Time History at F.S. 360, W. L. 0.0.

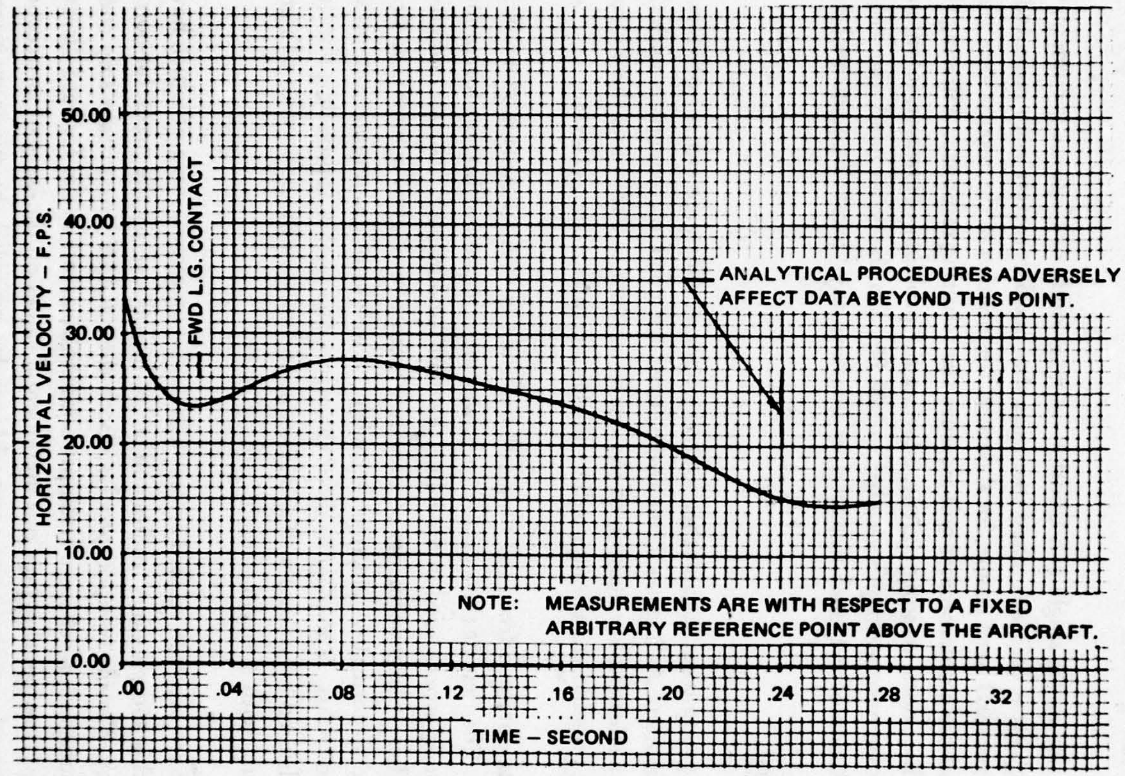

Figure 78. CH-47A Crash Test Film Analysis – Derived Horizontal Velocities at F.S. 360, W.L. 0.0.

- Calibration errors
- Phase shift and amplitude errors due to signal conditioning equipment used in data acquisition
- Processing errors

Of the above, the largest single contribution on magnitude of response is from installation effects. Although great care was taken to ensure that accelerometers were mounted, as far as possible, on structural hard points, local natural frequencies in the mount area are excited by the impact, and the accelerometer will measure the resulting response. Filtering the data using a 100-Hz LP filter does, to some extent, alleviate the problem. However, it will not eliminate the effect of local natural frequencies below 100 Hz. On the other hand, the structural model used for simulation of the crash impact does not have any "local" frequencies below 100 Hz.

Random Errors

These loosely group together all other sources of errors which are either not known or occur in a random fashion. As a general rule these errors are small in comparison with the previous two. Also, as a statistical evaluation of the crash test data to determine these errors is neither profitable nor possible, no attempt will be made to estimate their effects.

Analytical data obtained from the simulation of the CH-47A KRASH model will include several errors. The first of these is due to slower introduction of impact forces into the structure due to the approach used in modeling the main landing gear. The second arises from the lumping together of large segments of aircraft structure into a few elements and concentrating the distributed structural weight together with the weight of discrete mass items into the nodal "lumped" mass. The magnitude of the errors due to this approach is not known but can be large as indicated by studies in finite element analyses on the deflection of statically loaded cantilever beams with a varying number of segments.

Thirdly, there are program related errors such as coding errors, some of which have been identified during this and previous studies and errors introduced by the predictor-corrector routine employed in the solution process. Both the KRASH III constant step and the S-7900 variable step integration schemes attempt to minimize errors in the forward direction only and do not attempt recomputing previous incremental values on the basis of an acceptable error size. The approach can give quite acceptable results, provided the minimum integration time steps are kept quite small and the structural model behavior is fairly continuous. However, it was found during the simulation studies that gross errors occur if there are closely spaced element ruptures and several external springs in an "unload" condition.

Fourthly, the accuracy of the model simulation beyond the primary power stroke is questionable due to reasons discussed in Section 5.2.2.

In summary it can be concluded that, due to the presence of errors in test data, modeling techniques, and the KRASH code, correlation of test data with analytical results will show deviations with respect to amplitude and phase relationships where accelerations are concerned. These deviations will tend to grow larger after about 0.1 second, i.e., when the primary power stroke is completed. Deflection data will suffer less from these effects due to the "smoothing" effects of the integration process on the oscillatory portion of the errors.

6.2.2 Accelerations

6.2.2.1 Longitudinal Accelerations

A comparison of the decay in vehicle horizontal velocities at Station 320 and Station 360 shown in Figures 76 and 78 with the analytical data shown in Figure 67 indicates that the analysis overestimates the longitudinal deceleration of the vehicle. Friction coefficients used for the analysis are 0.5 at the landing gears to represent tire friction and 0.3 for the external springs representing the bottom surface of the fuselage. For typical landing gear spinup and springback calculations, a friction factor of 0.55 is recommended by military and civil aeronautical specifications. It is also well known that a flat tire tends to scrub and as such exhibits a higher coefficient of friction. Although definitive data for metal sliding on concrete do not exist, extrapolations of available information suggest coefficients of friction in the range of 0.2 to 0.7, depending on various surface conditions. Hence, the values used in the analysis were considered reasonable.

As indicated in Section 5.2.1, there is an unidentified error in the KRASH code which results in the model horizontal velocity being incorrectly computed. Actually, the model develops a "negative" velocity. It is believed that the coding problem results in incorrect computation of longitudinal accelerations. A summary comparison of the longitudinal acceleration data from test and analysis, in general, shows gross deviations. An exception to this is shown in Figure 79, which compares the longitudinal acceleration test data at F.S. 320, baseline cargo, with analytical predictions at F.S. 360, floor frame/side frame corner joint. Allowing for the difference in station locations and frequency and phase deviations, there is good agreement between the two sets of data. The predicted maximum acceleration is within 15% of the test value.

6.2.2.2 Vertical Accelerations

A preliminary comparison of the CH-47A KRASH model mass point locations with the accelerometer locations on the test aircraft shows that direct correlation of analytical results with test data is only possible at a few points. Secondly, the modeling techniques used to represent the main landing gear to overcome the skating problem encountered during simulation and the simplified representation of the structure tend to reduce the rate of introduction of load into the structure and to attenuate high-frequency response. Finally, due to problems associated

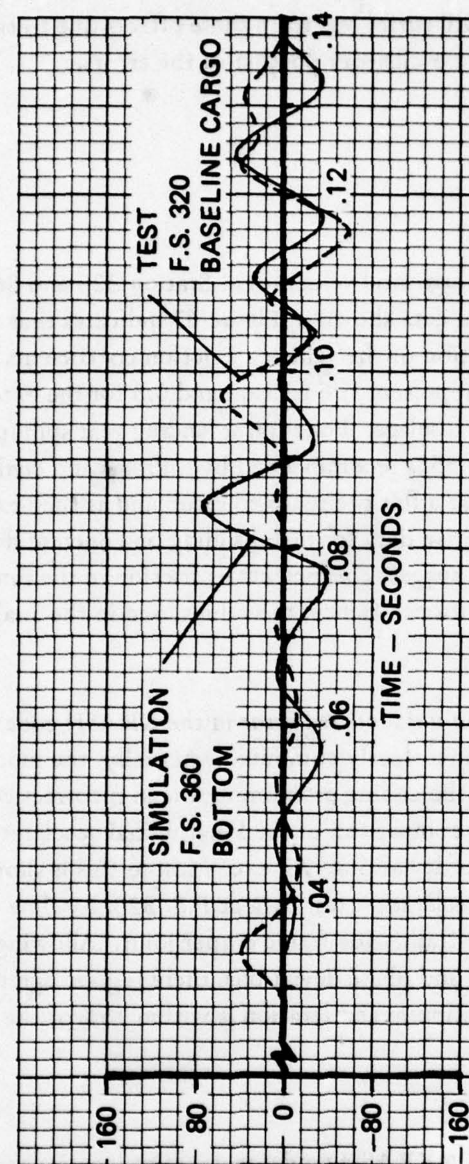

Figure 79. CH-47A KRASH Simulation – Longitudinal Accelerations at F.S. 360.

with the external spring element formulation in the KRASH code, the accuracy of the detailed response of the model beyond the primary power stroke decays rapidly.

In view of the above considerations, detailed correlations are presented only for a few points selected on the basis of their importance with respect to general crashworthiness. For ease of comparison, vertical acceleration data are shown in the figures using KRASH convention, i.e., negative acceleration acts in the upward direction. Relevant comparative data are summarized in Table 8. A brief discussion of individual results follows.

Main Landing Gear

In the CH-47A KRASH model, the effective weight at the main landing gear location is distributed between three mass points as follows (left side shown):

Node 11	=	236.5 lb
Node 12	=	161 lb
Node 37	=	97 lb
Total		494.5 lb

The analytical vertical acceleration at the main landing gear was obtained by combining the simulation data at mass points 11 and 12, using effectivity factors relating the nodal weights to the total weight. The results are compared with test data in Figure 80. During initial impact, the analysis predicts an upward acceleration of 115 g, which is about 25% higher than the test value of 90 g. Also, the maximum frequency placements are within 0.0009 second of each other. Beyond 0.01 second, however, there is no correlation between the two sets of data. The test data shows the effect of recoil, whereas the model data shows virtually no load. This is due to the program modeling constraints discussed earlier.

Forward Transmission

The acceleration data from test and analysis are compared in Figure 81. It can be seen from the figure that the analysis lags considerably behind test data. The lag is explained by the slow introduction of load by the second set of external springs used to model the landing gear. Allowing for the resulting phase shift, the analysis predicts a maximum upward acceleration of 119 g, which is reasonably close to the test value of 88 g.

Cockpit Floor

Figure 82 compares analytical and test data for the vertical accelerations at the floor under the crew seat. The analytical data correlates closely with test data at maximum amplitude both in terms of magnitude and placement. The lag in acceleration buildup is caused by reasons discussed earlier.

TABLE 8. CH-47A (KRASH) – COMPARISON OF ANALYTICALLY PREDICTED ACCELERATIONS WITH TEST DATA (VERTICAL DIRECTION)

Location	Max (-ve)[a]				Min (+ve)			
	Value (g)		Time (sec)		Value (g)		Time (sec)	
	Analysis	Test	Analysis	Test	Analysis	Test	Analysis	Test
Fwd Transmission	120	88	0.06	0.0375	50	18	0.086	0.055
Cockpit Floor	152	116	0.056	0.053	–	95	–	0.04
Main Ldg Gear	112	90	0.035	0.045	–	103	–	0.02
F.S. 360 Floor ℄	80	130[b]	0.108	0.107	–	–	–	–
F.S. 360 Floor Left	110	100[c]	0.107	0.098	80	70[c]	0.126	0.107
F.S. 482 Floor ℄	70	57[d]	0.142	0.140	28	36[d]	0.174	0.121
Left Engine ℄	46	48	0.144	0.13	36	–	0.12	–

NOTES: a. -ve acceleration is upwards.
b. At F.S. 370
c. At F.S. 320
d. At F.S. 460

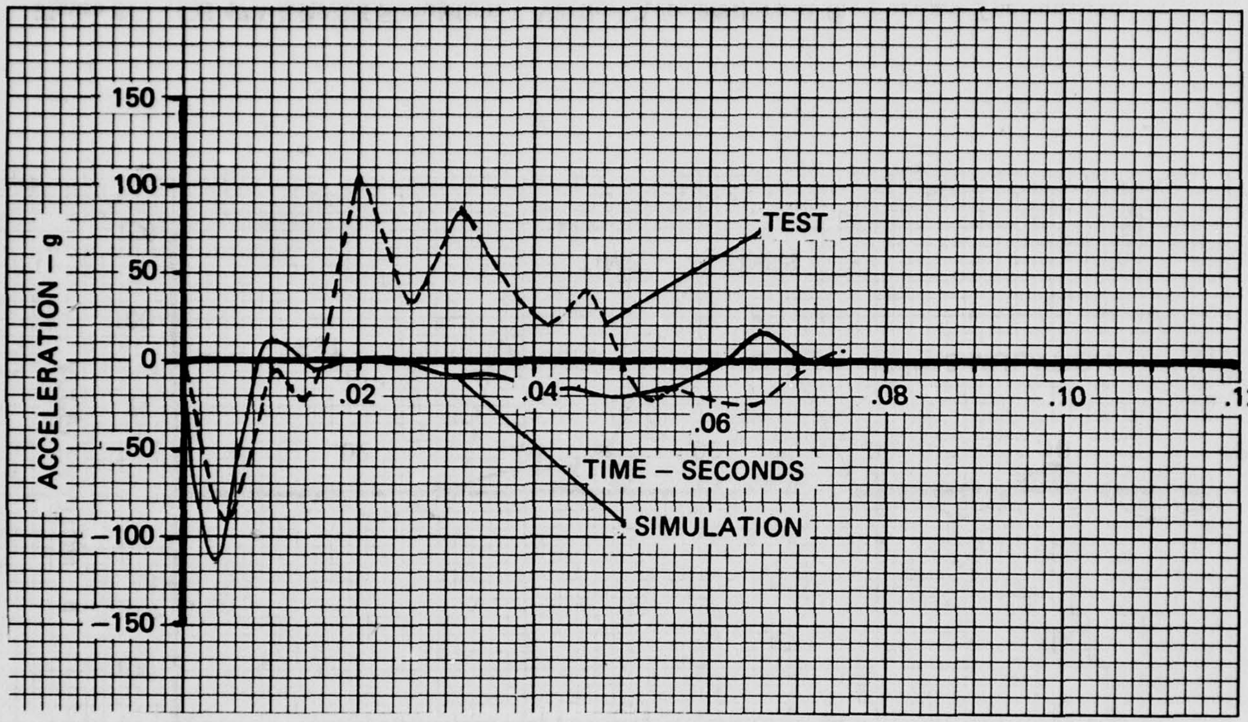

Figure 80. CH-47A KRASH Simulation – Vertical Accelerations at Main Landing Gear, F.S. 240.

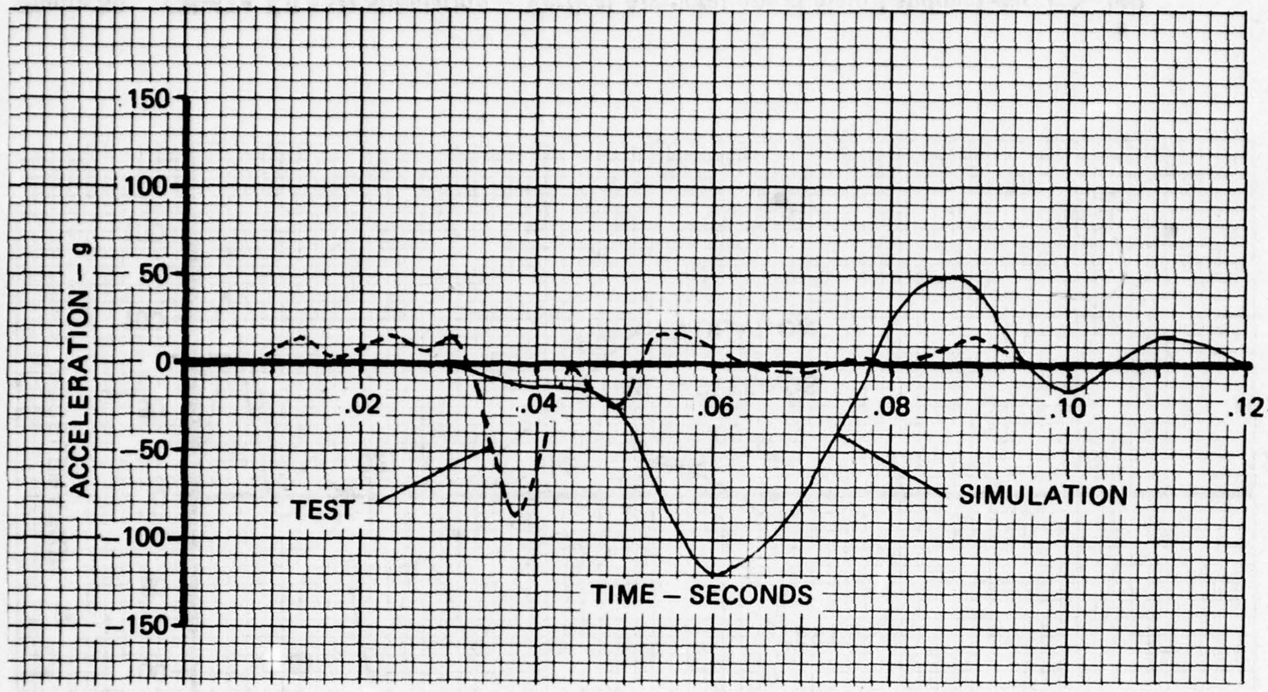

Figure 81. CH-47A KRASH Simulation – Vertical Accelerations at the Forward Transmission.

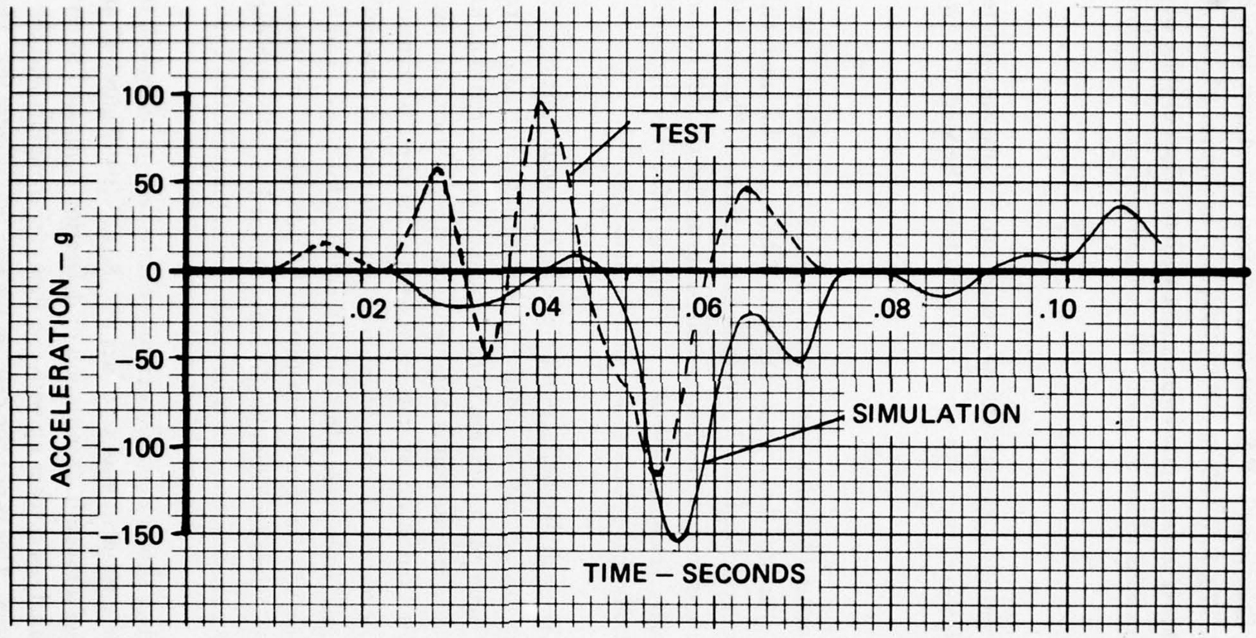

Figure 82. CH-47A KRASH Simulation – Vertical Acceleration at Cockpit Floor Under Crew Seat.

Cabin Floor

The analytical predictions for vertical accelerations along the cabin floor centerline at F.S. 360 and 482 and at the side frame/floor joint at F.S. 360 are compared to test data from closely situated accelerometers at F.S. 370, F.S. 460, and F.S. 320 (side) in Figures 83, 84, and 85, respectively. The analytical data is in fairly good agreement with test data in spite of the fact that the test data applies to locations which are up to 40 inches away from the analysis locations.

Left Engine

Figure 86 compares the accelerations at the left engine determined by analysis with test data. If the phase shift indicated is ignored, there is a very close agreement between the two results.

6.2.3 Deflections

The deflections at discrete structural locations obtained by double integration of test acceleration data are not directly useful as the local axes and the inertial axes are inclined with respect to each other by varying amounts throughout the crash impact sequence. The analytically determined accelerations are computed in the moving body axes as also the deflections obtained by integrating the test data. Hence, without a voluminous amount of data analysis, direct comparisons of test and analytical deflections cannot be made.

The test aircraft instrumentation included deflection poles which provide time histories for cabin height reduction at three fuselage station locations. Although these station locations do not coincide exactly with any mass point location in the structural model, the time histories of the position coordinates of spanwise mass points obtained from the analyses were used to generate plots of cabin height reduction versus station location along three buttlines at successive time intervals. The analytical time histories of cabin height reductions at the deflection pole locations were then obtained from these plots by interpolation for station and buttline location. The results are compared with test data in Figures 87 through 90 and 92. Figure 91 shows a comparison of analytical data for cabin height reduction at F.S. 240 with data obtained by interpolating from test measurements. The results are summarized in Table 9.

A review of the comparative data shows that, if oscillatory excursions are excluded, the analytical data are in excellent agreement with test data at F.S. 125 (see Figures 87 and 88). At. F.S. 284, the analysis shows a much later initiation of deflection compared to test data. On the right side, Figure 89, the analysis catches up with test data rather rapidly and the final deflections are essentially the same. This is not the case on the left side, Figure 90. Test data show that cabin height reduction was considerably less here than in the right side, whereas the analytical data are somewhat more symmetric. It is possible that the test data beyond 0.12 second are inaccurate due to the effect of local floor buckling on the deflection pole.

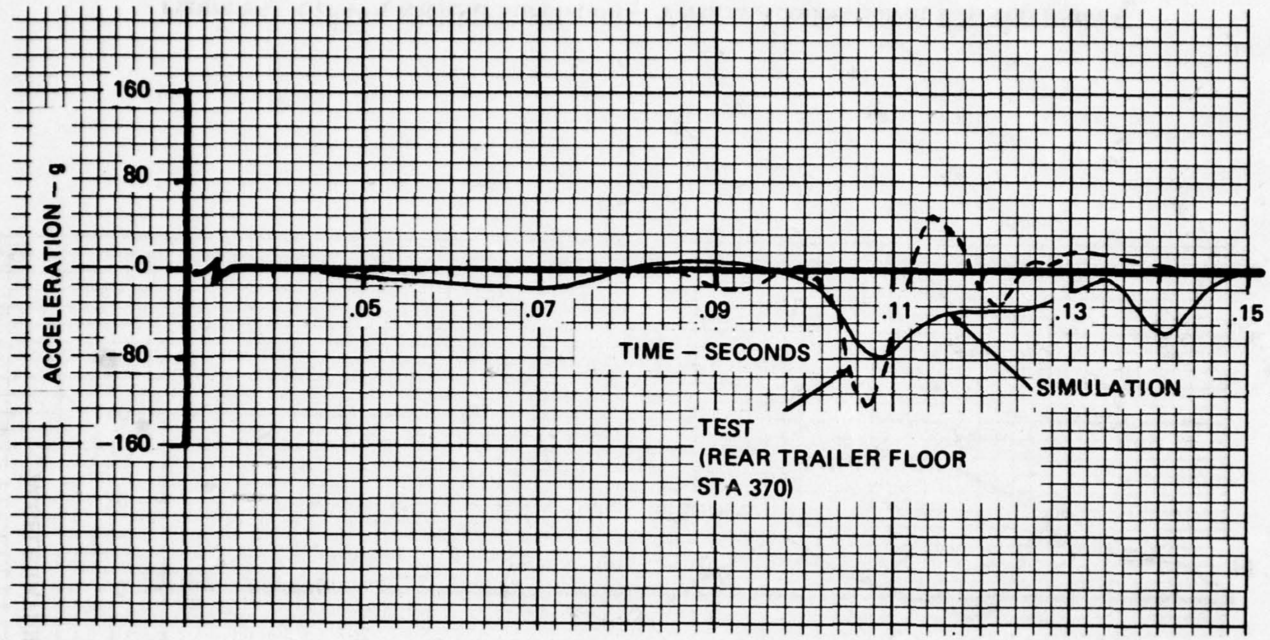

Figure 83. CH-47A KRASH Simulation – Vertical Acceleration at F.S. 360 Floor ℄.

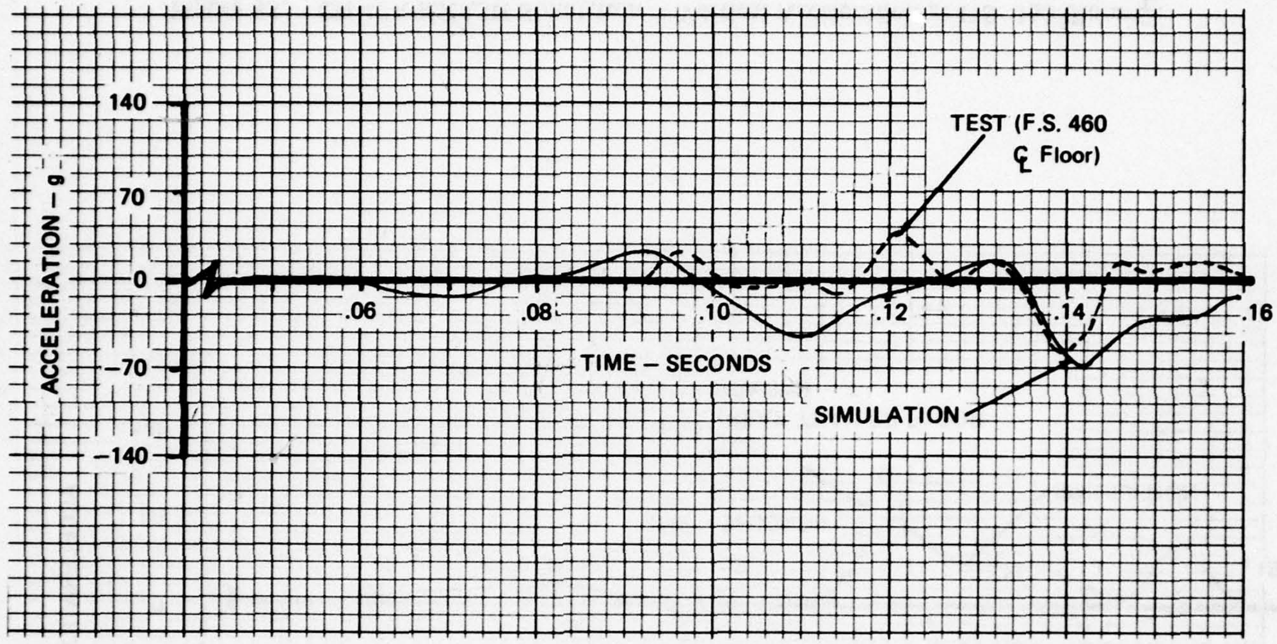

Figure 84. CH-47A KRASH Simulation – Vertical Acceleration at F.S. 460 Floor ℄.

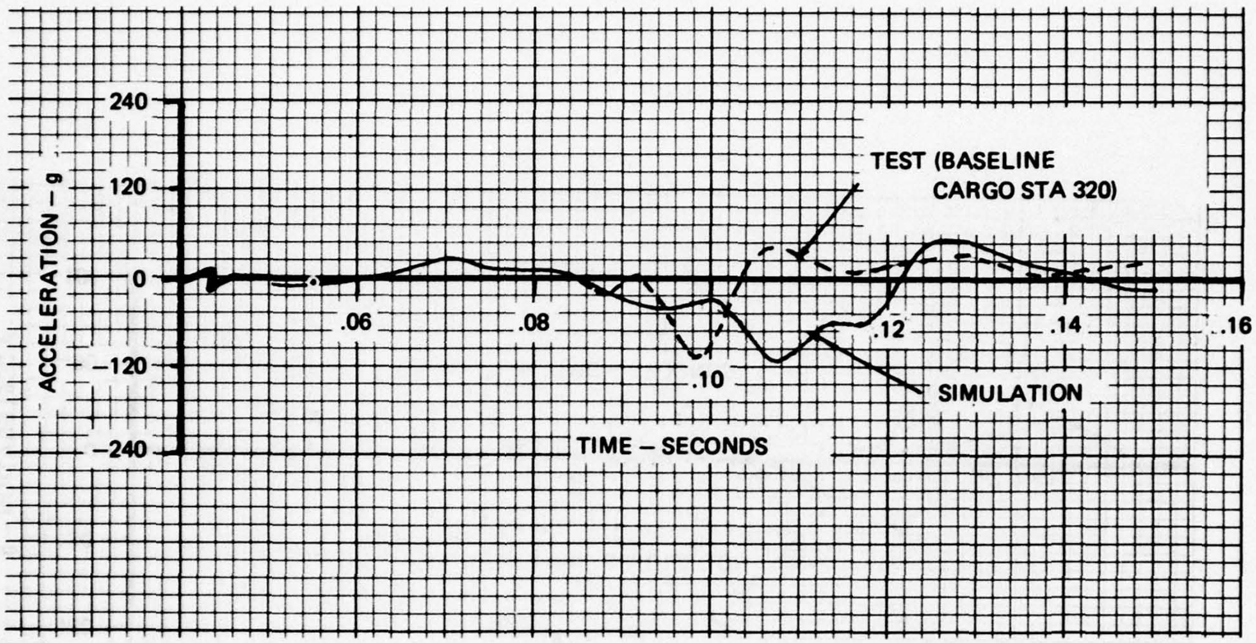

Figure 85. CH-47A KRASH Simulation – Vertical Acceleration at F.S. 360 Bottom/Side.

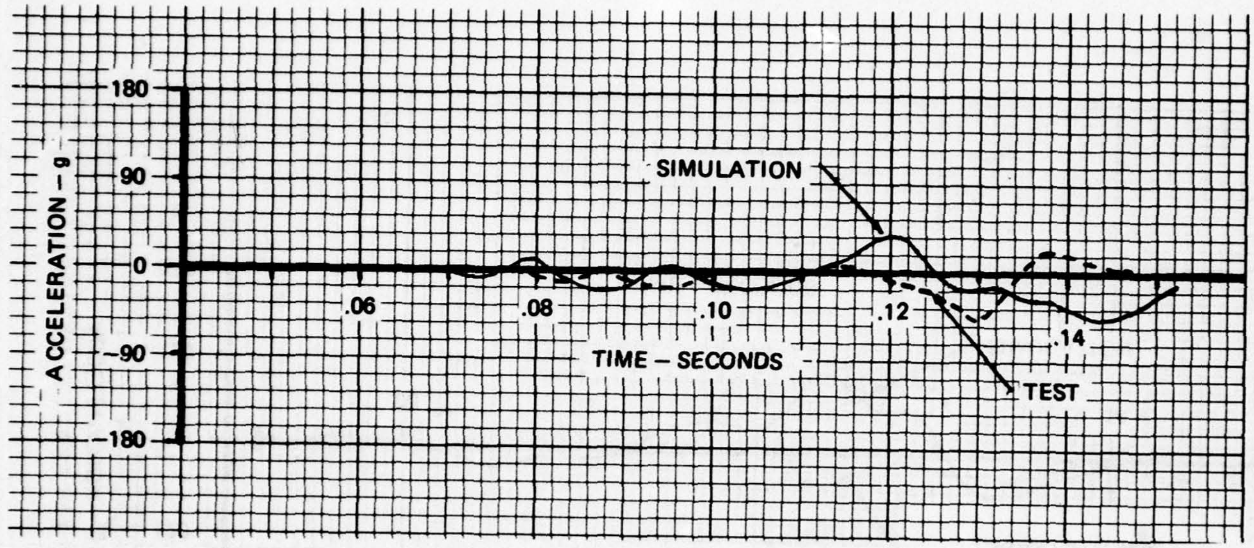

Figure 86. CH-47A KRASH Simulation – Vertical Acceleration at Left Engine C.G.

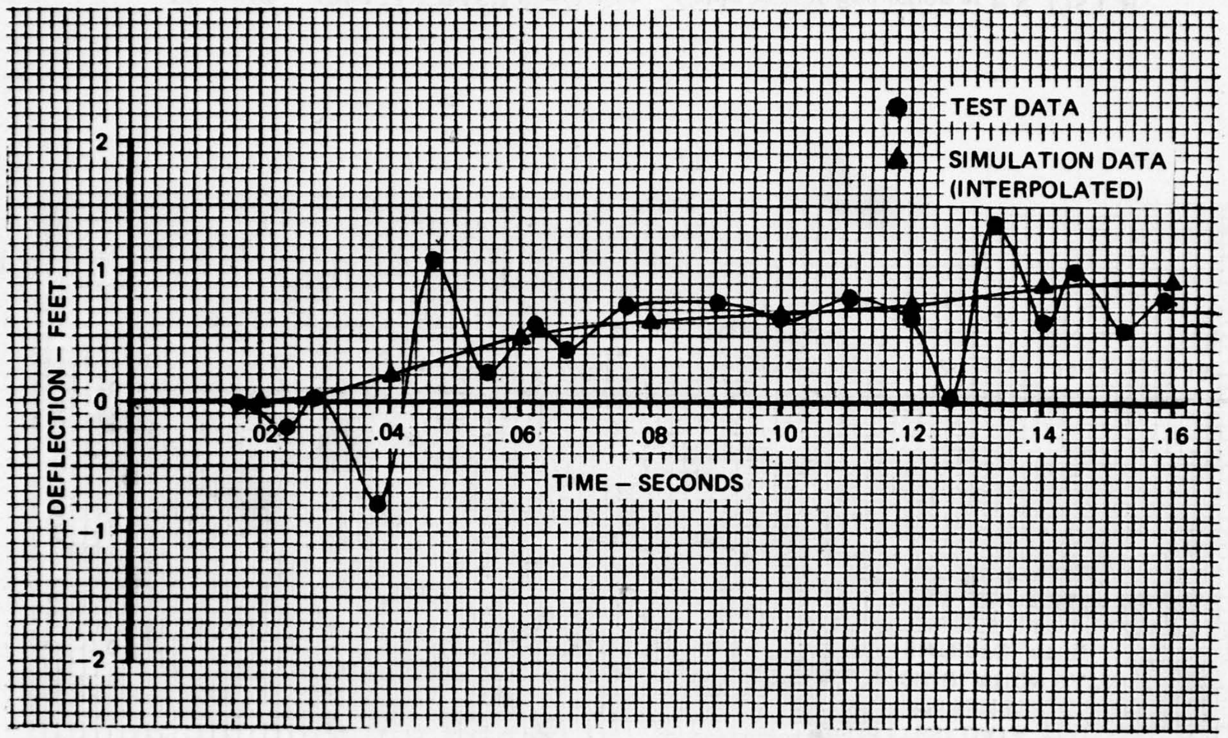

Figure 87. CH-47A KRASH Simulation – Cabin Height Reduction at F.S. 125 R.H.

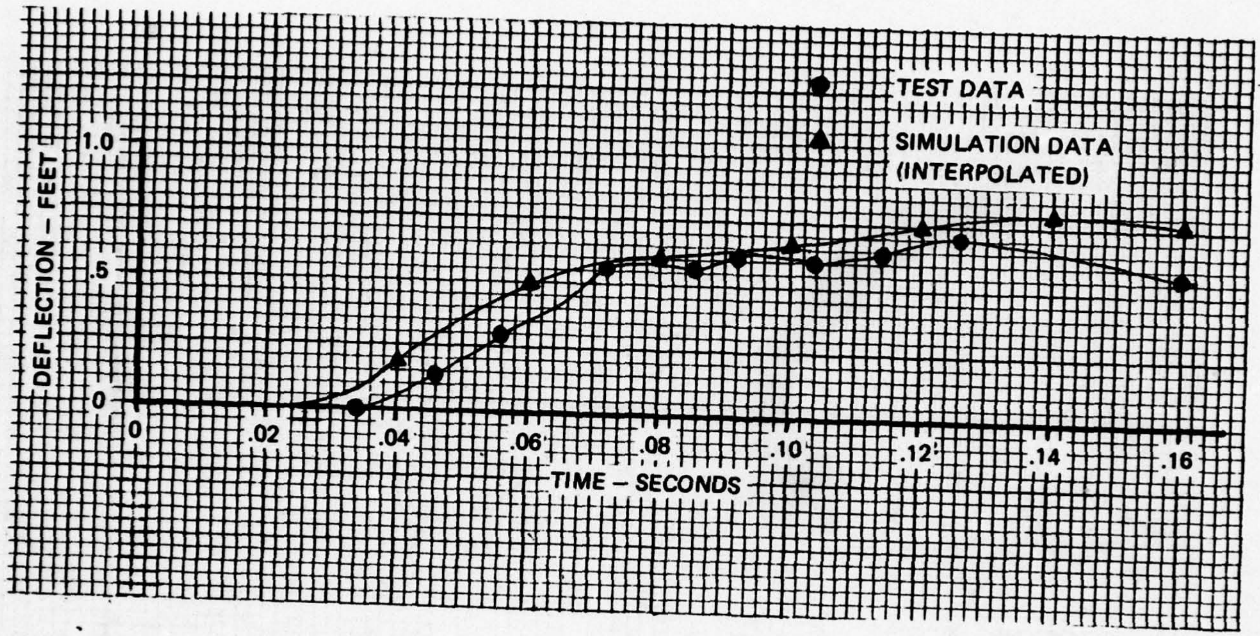

Figure 88. CH-47A KRASH Simulation – Cabin Height Reduction at F.S. 125 L.H.

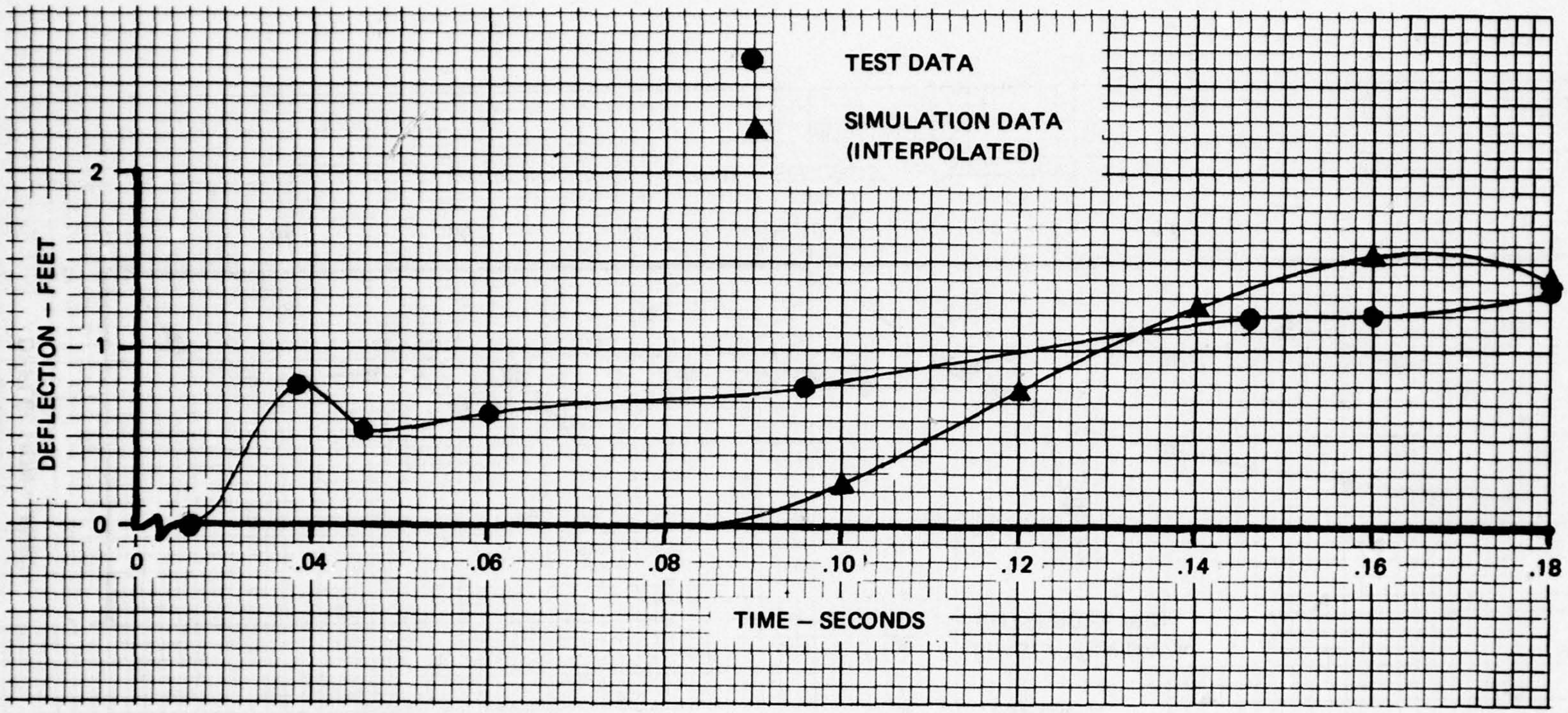

Figure 89. CH-47A KRASH Simulation – Cabin Height Reduction at F.S. 284 R.H.

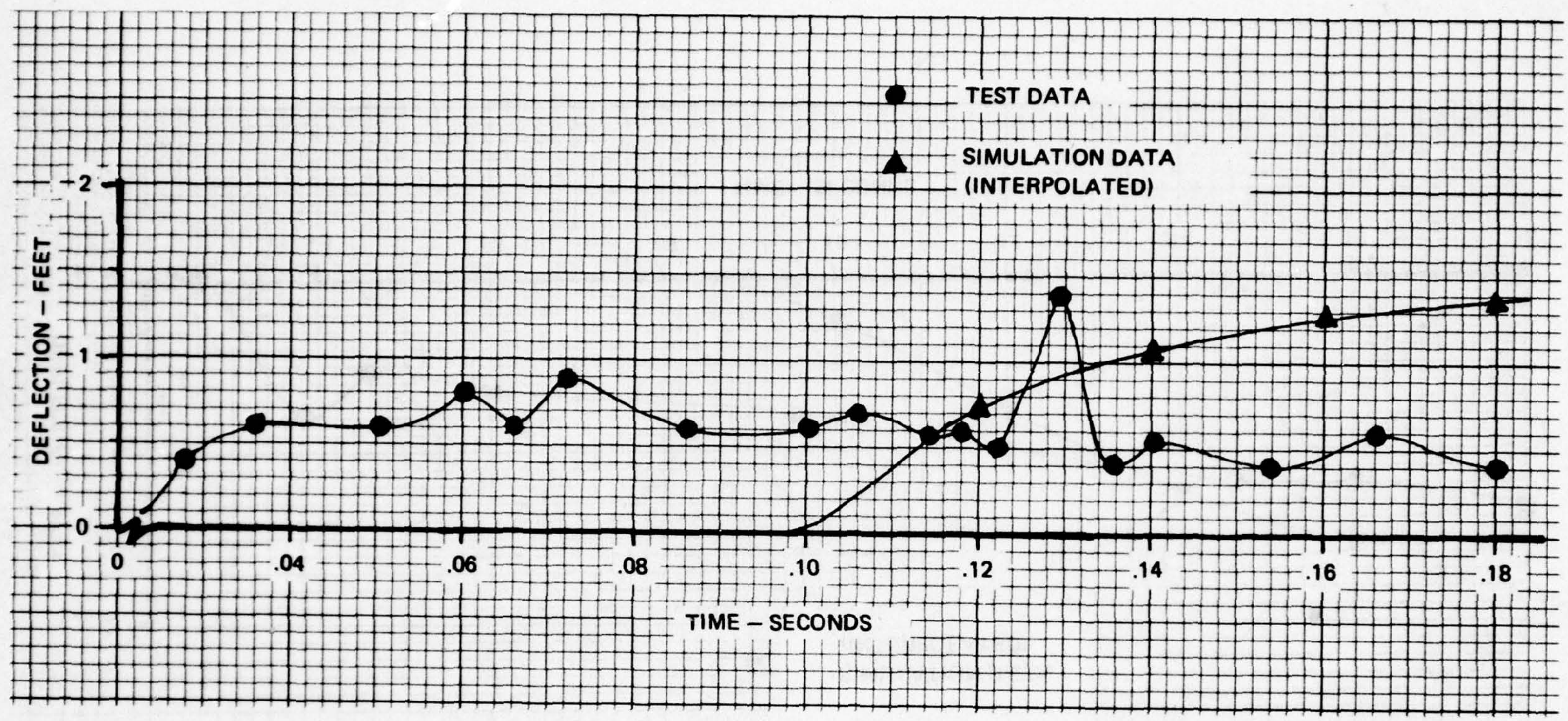

Figure 90. CH-47A KRASH Simulation – Cabin Height Reduction at F.S. 284 L.H.

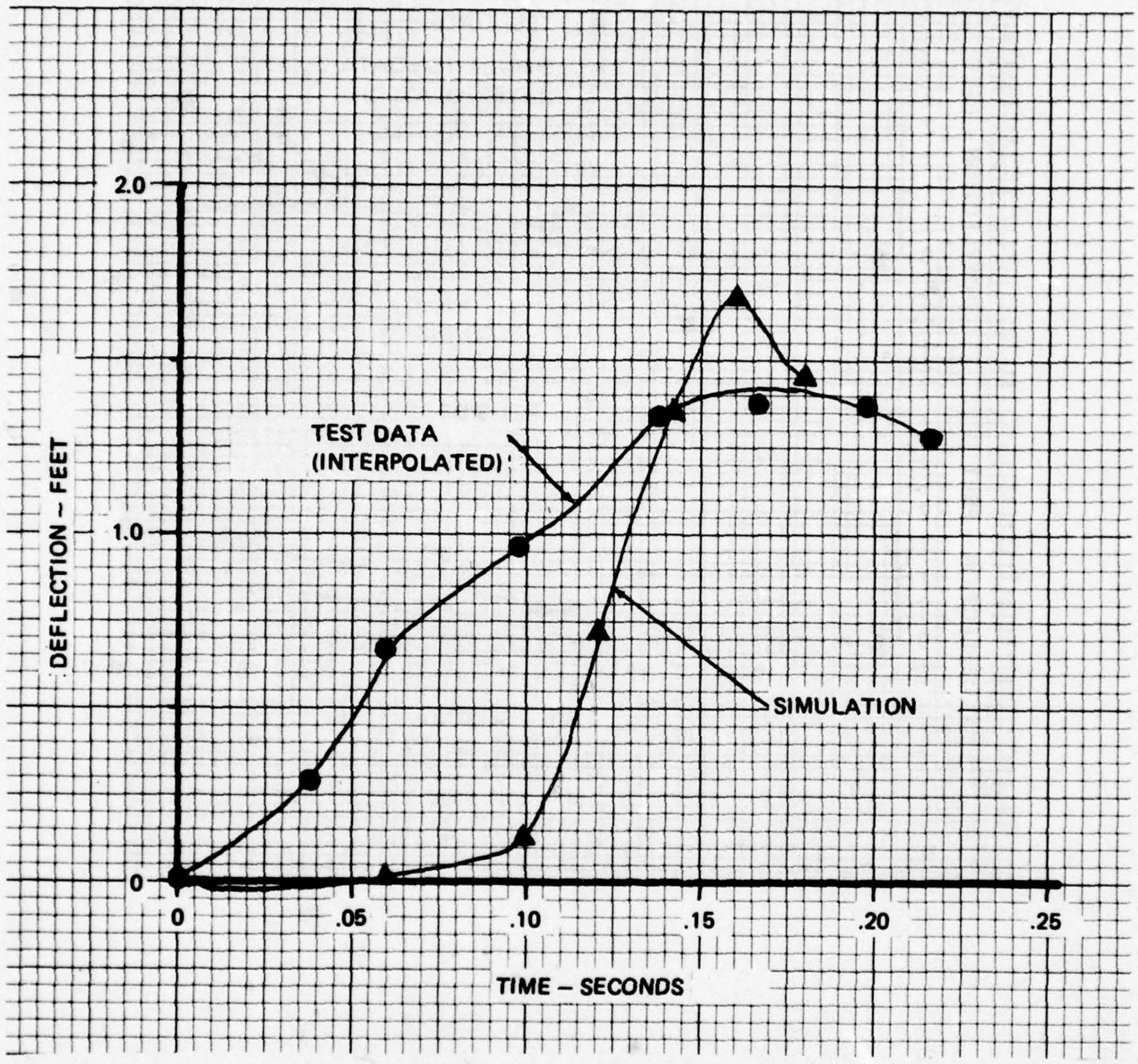

Figure 91. CH-47A KRASH Simulation – Cabin Height Reduction at F.S. 240.

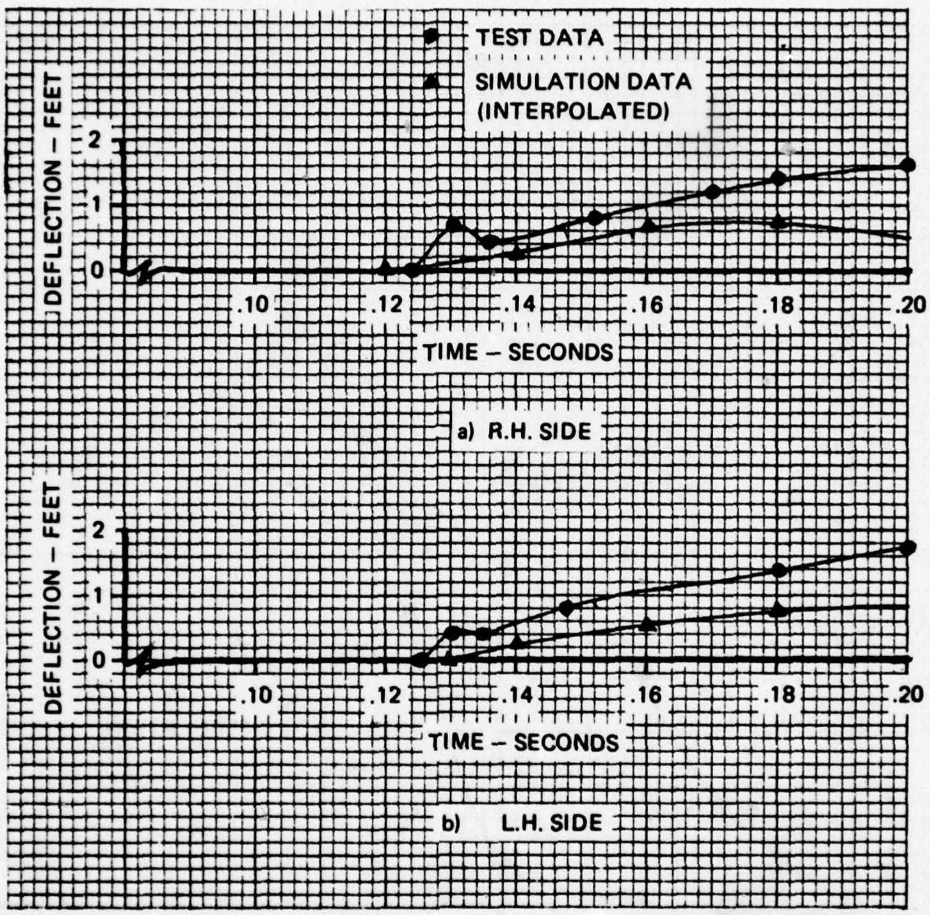

Figure 92. CH-47A KRASH Simulation – Cabin Height Reduction at F.S. 455.

TABLE 9. CH-47A CRASH IMPACT ANALYSIS – PREDICTED CABIN HEIGHT REDUCTION VERSUS TEST DATA

Location	δ_{MAX}(ft) Analysis (1)	δ_{MAX}(ft) Test (2)	Deviation (%) $\left[\frac{(1)-(2)}{(2)}\right] \times 100$	Time at δ_{MAX} (sec) Analysis	Time at δ_{MAX} (sec) Test
F.S. 125 Right	0.96	0.85 [a]	12.9	0.154	0.154
Left	0.80	0.70	14.3	0.140	0.126
F.S. 240	1.67	1.42	17.6	0.160	0.165
F.S. 284 Right	1.55	1.35 [b]	15.5	0.166	0.18
Left	1.37 [b]	c	c	0.18	0.18

NOTES: a. Value based on estimated mean curve

b. Not a maximum. Value at time shown

c. Test value is suspect.

Figure 91 also shows that, although analytical predictions for F.S. 240 initially lag test data as at F.S. 284, the predicted value for maximum height reduction is at about the same time as and within 18% of the test maximum.

On the other hand, an examination of the data for F.S. 455 in Figure 92 (a) and (b) shows a considerable difference between analytical and test data. The test values are still increasing at 0.20 second, whereas the analytical values are past or nearing their maximums. Also, the analytical maximums are about 50% of the test data at 0.2 second.

6.3 SUMMARY AND DISCUSSION OF RESULTS

A review of the summary comparisons shown in Figure 70 and Tables 8 and 9, as well as the time history data in Figures 79 through 92, indicates that, in general, the dynamic response obtained from simulation of the improved CH-47A KRASH model agrees reasonably well with the data obtained from the CH-47A crash test. There are, however, detail variations which will be discussed now.

The general kinematics of the test aircraft are duplicated by the model response within a few milliseconds during the initial 120 milliseconds after impact. Thereafter, the model behavior deviates rapidly from that of the test aircraft. This deviation may, in part, be due to the rapid deceleration of forward velocity of the model as well as unidentified coding errors in the treatment of ground friction. Further, in the model response, there is a short period of time after the first beam element in the main landing gear representation is ruptured and the second external spring has not yet contacted the ground. During this time interval, no external forces are induced into the vehicle. This results in the model response lagging the actual response of the test article.

The sources for and possible effects of errors both in the test data and from the modeling technique employed here have been discussed in some detail in Section 6.2.1. Although no precise estimate of the magnitude of these errors is possible in this case, initial velocity estimates alone may result in errors of up to 10% in the analytical results for mass accelerations in the vertical direction. The total effect from all error sources may well exceed twice this amount. Further, the absence, in the model, of landing gear recoil effects and the lag in response noted earlier lead to increasing phase and amplitude errors in the model response data. The comparative data in Table 8 show that the deviations in maximum values for vertical accelerations are within acceptable limits.

In the case of displacements, the effect of some of the errors in the analytically determined accelerometer data may be minimized through the smoothing effect of the double integration process employed. Thus a closer correlation between analytical and test data for deflections in regions not directly affected by external spring rebound effects can be expected. This is borne out by the comparisons shown in Table 9, where the maximum deviation between the

cabin height reduction values derived from analysis and test data is less than 18%. The deviation is considerably higher at F.S. 455 where the later response is affected by the rebound of all external springs in the forward areas.

In summary it can be stated that, except in the longitudinal direction, the analytical results obtained by S-7900 simulation correlate excellently with test data up to about 130 milliseconds after impact. The correlation deteriorates after this point due primarily to KRASH code limitations.

6.4 KRASH PROGRAM VALIDATION

The KRASH III computer program as received at Boeing Vertol was developed by Lockheed-California under Army sponsorship (see Reference 1). During the course of the efforts under this contract, the capabilities of the KRASH were enhanced by incorporating several improvements as well as corrections to minor coding errors. This improved program is entitled S-7900.

Throughout the course of this study, a large number of computer runs was conducted utilizing KRASH III and S-7900. The capabilities of KRASH to simulate the dynamic response of a helicopter to a crash impact have been explored in great detail. These efforts have led to a better understanding of the limitations existing in the KRASH program and also to an extension of the validity of the program for use as a design tool for the analysis of airframe structural crashworthiness. The results are summarized in Table 10.

TABLE 10. KRASH PROGRAM VALIDATION STATUS AND CURRENT LIMITATIONS

Item/Requirement	KRASH III Validation (Ref 1)	Extended Capability (S-7900)	Comments/Limitations
Crash Environment Translational velocities Rotational velocities Aircraft Attitudes Impact angle	● Translational velocities, pitch attitude, impact angle ● Ground friction	● Can handle pitch velocity as initial conditions	● Effect of initial roll, yaw velocities, and attitudes can be destabilizing. ● Treatment of frictional effects appears to be in error and needs review. ● External spring element logic is incorrect.
Airplane Configuration	● Single-rotor helicopter with skid under-carriage ● Simple box structure modeled with fixed-fixed beams ● Gross dynamic behavior	● Large tandem-rotor helicopter with quadricyclic landing gears ● Complex semimonocoque structure ● One-sided elements permit modeling diagonal tension effects.	● Extreme care required in modeling landing gear behavior with external spring element ● Needs element to represent oleo behavior during recoil ● Limited number of permissible elements in model restricts ability to obtain detail response.
Structural Behavior	● Nonlinear structural behavior defined by means of stiffness reduction factors (KR tables) ● Coupling effects not examined	● Restart capability permits adjustment of KR factor to minimize gross errors in force and energy computations. ● Large deflection correction improves accuracy.	● Crude approximation of post-yield behavior ● Requires modifications to include coupling effects between strain components on yield and rupture

TABLE 10 – Continued

Item/Requirement	KRASH III Validation (Ref 1)	Extended Capability (S-7900)	Comments/Limitations
Multiple Impacts	● Limited to a single impact, very little rebound effects ● Multiple impacts cannot be modeled.	● Limited capability to model successive impacts on separate external springs. Accuracy lost when most springs are in rebound condition.	● External spring computes incorrect loads during unload/reload cycles.
Stability of Solution Process	● A forward predictor-corrector routine utilizing constant integration time step ● Stable solutions over small number of iterations ● Element ruptures have destabilizing effect.	● Improved forward predictor-corrector routine employing a variable integration time step reduces potential divergence ● Improved treatment of element ruptures improves stability.	● Requires improved numerical analysis techniques to maintain a stable solution flow
Use as Design Tool	Not applied	Not applied	● Potentially applicable. Results obtained are highly sensitive to modeling assumptions and small variations in element properties.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Based on the investigations reported here, it can be concluded that:

(a) Although KRASH needs further improvement, it is a useful tool for evaluation of structural crashworthiness and a significant advance in analytical methodology available for the purpose.

(b) The KRASH program, S-7900 version, with certain limitations, provides an acceptable method for obtaining the dynamic structural response during the primary power stroke of large helicopters in a crash impact environment.

(c) The program can be employed to estimate the overall decrease in the volume of occupied areas.

(d) Parametric evaluation of different structural arrangements during preliminary design states can be performed with KRASH provided great care is exercised in constructing the structural models.

(e) The external spring logic in KRASH is in error and does not represent fully the action of crushable structure.

(f) Behavior of oleo struts cannot be represented by available elements in KRASH.

(g) With some simplification of the program and incorporation of recommended improvements, the usefulness of KRASH as a design tool for incorporating structural crashworthiness into an airframe during the early design stages will be greatly increased.

7.2 RECOMMENDATIONS

Several of the shortcomings and coding errors which severely limit the capabilities of KRASH have been discussed in previous sections. Suitable improvements and corrections should be incorporated into the KRASH program in order for it to be used in the detailed and accurate analysis of aircraft structural crashworthiness. In addition, the usefulness of KRASH as a design tool will be further enhanced if certain input/output facilities are incorporated into the program. Pertinent recommendations follow:

- Incorporate suitable corrections to external spring load calculation methodology in KRASH to eliminate improper loads being calculated during load/unload/reload cycle.

- Review in detail the formulation of the basic equations of motion and their integration scheme in DERIV to determine sources of errors which result in nonsymmetric solutions to symmetric problems. (An attempt to resolve this problem in KRASH (B/V) was only partially successful.) Necessary corrections should be incorporated into KRASH.

- Analyze treatment of ground friction in KRASH to determine causes for the reversal of forward velocity obtained in the CH-47A crash simulation studies and install required coding changes. Also include frictional energy separately in the printout.

- Develop and incorporate methodology to properly account for total strain in the computation of beam element loads in the plastic zone. The existing methodology in KRASH uses independent KR factors applied to each term in a beam element stiffness matrix. This does not account for proper interactions between the strains in all six '1' directions at onset of yield and results in large errors in beam loads and strain energy computations.

- A more rational methodology to predict beam element rupture is required. It should be based on an acceptable failure criterion using combined strain effects. KRASH now calculates element rupture when the strain in any one direction exceeds the rupture strain defined for that direction. This can cause very large errors in the magnitude of loads computed at rupture for highly loaded beam elements.

- KRASH element vocabulary should be expanded to include a spring/damper-type element capable of representing landing gear behavior.

- Provide a total energy balance routine. The energy distributions are computed in KRASH III. However, this information is not used to flag decay in solution processes. It will save a considerable amount of computer time if a routine were to be incorporated which terminates program execution if the total energy of the system departs from initial values by specified control levels. This will help the analyst identify and correct modeling or other problems which cause the deviations.

- Considerable savings in preparation time and data analysis will be achieved by including the following user-oriented options:

  (a) Internal computation of stiffness matrices from basic structural data.

  (b) Several general types of KR shapes. User to specify type required for each beam element. Special types would still be input.

(c) Printout of all results at each instant of element rupture and external spring-to-ground contact. This will aid the analyst to understand better the dynamics of the problem since it is primarily at these instances that significant changes in element forces, mass accelerations, and velocities occur.

(d) Internal computation and printout of the relative displacement between several selected mass points. This will eliminate a considerable amount of manual data processing to ascertain information such as reduction in the volume of occupied areas.

(e) Printout to include center of gravity and attitude of vehicle.

<u>NOTE:</u> User options (a) and (b) are available in another version of KRASH (see Reference 28).

In addition to the above recommendations for improving KRASH, some of the gross errors affecting interpretation of crash test data can be minimized by:

- Provision of fixed vertical and horizontal reference lines in the impact area which should be clearly visible in the movie films of the impact test. This will permit a reasonably accurate estimate of impact velocities and attitude.
- Including a ground contact indicator in the test article instrumentation package. This will provide a definitive time zero for the test data.

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APPENDIX A

SAMPLE CALCULATIONS FOR CH-47A KRASH MODEL STRUCTURAL PROPERTIES

1. Center fuselage bending strength.

Figure A-1 shows a typical section of center fuselage area. In order for the model bending strength in the area to match the ultimate bending strength of the fuselage area for dynamic loading conditions, it is necessary that the section properties of the model shall show the same distribution of effective material as in the real aircraft with actual values adjusted to reflect expected improvement in strength resulting from rapid application of loads.

The properties of the section shown are computed in Table A-1. The calculations are grouped to reflect composition of the CH-47A crash model longitudinal beam elements. A segment of the CH-47A model is shown in Figure A-2. The model beam element properties were calculated with some redistribution necessitated by the model geometry and using a dynamic bending strength factor of 1.20. The section properties for the model are shown in Table A-2. The model properties show that the section centroid is in error by about an inch, and the bending strength reflects a 27% increase. This was considered to be acceptable.

2. Fuselage skin elements.

The theoretical ultimate strength of the side skin elements with an effective total height equal to 83 inches is given approximately by:

$$\underset{(\text{kips})}{V_{ULT}} = 22\,(19\text{x}.025+30.5\,\text{x}.032+21.5\text{x}.016) + 12\text{x}23\text{x}.040 = 50.5$$

This assumes development of full diagonal tension in all skin panels at the same time. However, the variations in skin panel thicknesses and reduction in effective support provided by edge elements rarely allow these values to be achieved. Analysis of some of the test data in Reference 31 indicates that under these conditions, the ultimate strength will be reduced by about 30%, i.e., to 35.3 kips. For the one-sided element in the CH-47A KRASH model representing the diagonal tension strength of the skin element, the average equivalent ultimate strength is given by:

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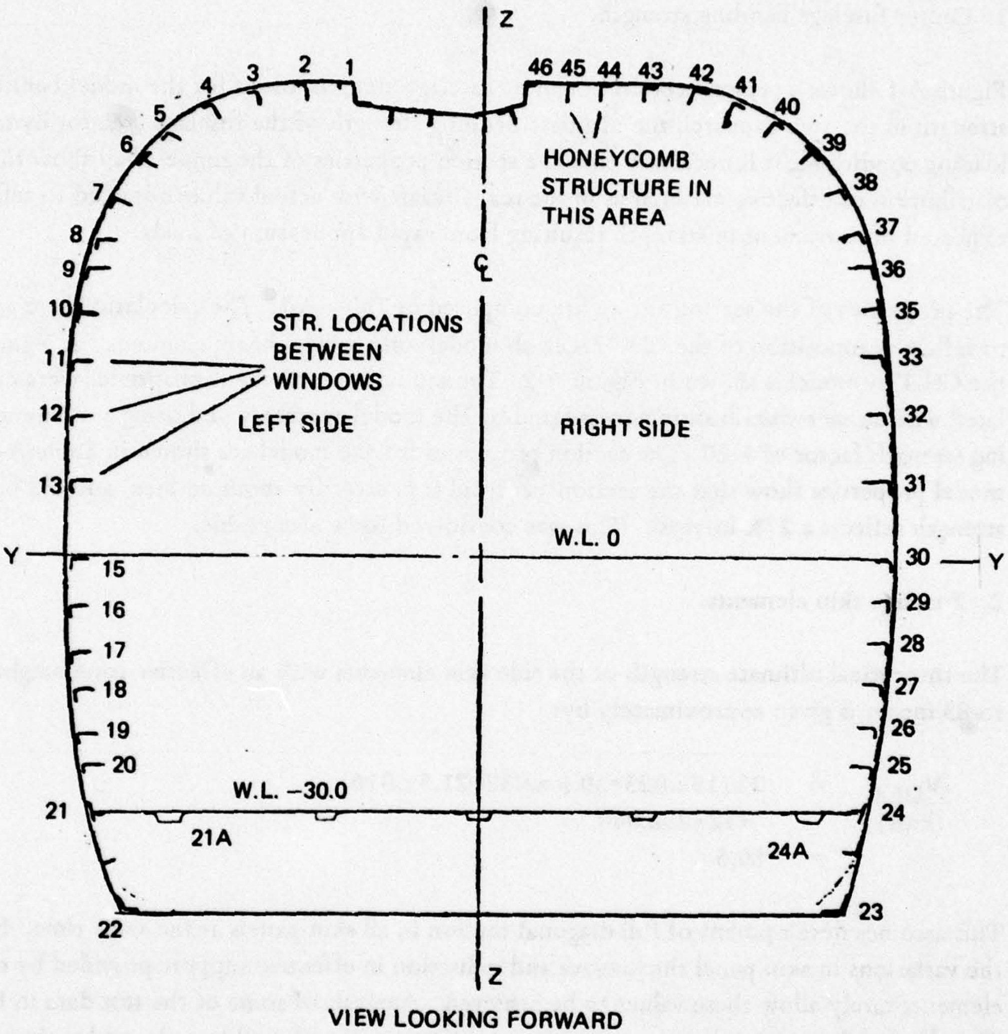


Figure A–1. Typical Cross Section of the CH-47A Center Section Showing Stringer Location, F.S. 160 to F.S. 440.

TABLE A–1. CH-47A CENTER FUSELAGE SECTION PROPERTIES

Str No.	Effective Area, A ($in.^2$)	z (in.)	Az ($in.^3$)	Az^2 ($in.^4$)	Model Element (see Figure A–2)
3	0.0587	54.88	3.22	176.8	
4	0.0587	53.51	3.14	168.1	b-h
5	0.0587	50.77	2.98	151.3	(f-l)
6	0.7095	46.74	33.16	1,550.0	
7	0.0198	42.46	0.84	35.7	
8	0.0198	37.87	0.75	28.4	
9	0.0198	33.47	0.66	22.2	
10	0.1442	28.96	4.18	121.9	
Subtotal	1.0892	44.92	48.93	2,253.4	
15	0.2337	0	0	0	
16	0.0198	– 5.70	– 0.11	0.6	c-i
17	0.0198	–10.80	– 0.21	2.3	(e-k)
18	0.0198	–16.19	– 0.32	5.2	
19	0.1570	–20.83	– 3.27	68.1	
20	0.1570	–25.49	– 4.00	102.0	
21	0.6670	–30.19	–20.14	607.9	
21A	0.4220	–30.04	–12.68	380.8	
22*	1.2800	–41.70	–53.37	2,225.8	
Subtotal	2.9761	–31.62	–94.10	3,392.7	
2	0.0587	55.50	3.26	180.8	
1	0.2260	55.45	12.53	694.9	
46	0.1969	55.43	10.91	605.0	a-g
44	0.1718	55.8	9.59	534.9	
43	0.0587	55.5	3.26	180.8	
Subtotal	0.7121	55.54	39.55	2,196.4	
Total (Full Section)	8.8427	– 5.74	–50.79	13,489	

*Includes contribution from bottom skin

$I_{yy} = 13,489 - 8.8427 \times 5.74^2 = 13,197 \text{ in.}^4$

TABLE A–2. CH-47A KRASH MODEL SECTION PROPERTIES (PRETEST)

Beam	Area	z	Az	I_{oy}	Az^2
a-g	.71	55.5	39.4		2187
b-h	1.39	46.6	64.8	104	3020
c-i	2.67	-36.0	-96.1	400	3460
d-j	.6	-36.0	-21.6		778
e-k	2.67	-36.0	-96.1	400	3460
f-l	1.39	46.6	64.8	104	3019
Total	9.43	- 4.75	-44.8	1008	15924

$$\therefore I_{yy} = 16719 \text{ IN}^4$$

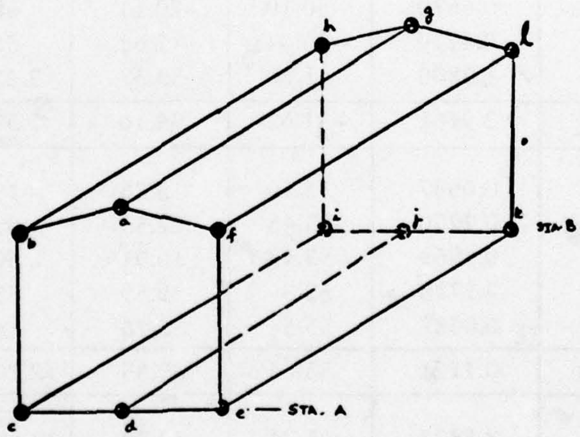


Figure A–2. Typical Center Section Segment – CH-47A KRASH Model.

$$T_{ULT} = (35.3)/\sin\left(\tan^{-1}\frac{83}{130}\right)$$

$$= 65.6 \text{ kips}$$

with F_{tu} = 62 kips, the effective area of the member is calculated to be

$$A_{eff} = \frac{65.6}{62} = 1.058 \text{ in.}^2$$

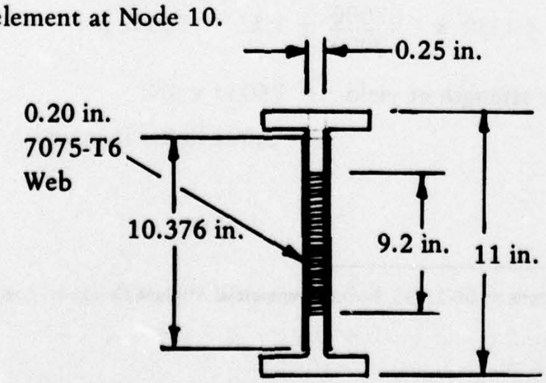
Area used in model = 1.05 in.^{2}

3. Typical floor beam element.
   (Element c-d)

Several types of floor beams are used in the CH-47A center section area. The section properties of all the intermediate frames at Fuselage Stations 180, 220, 300, and 380 are essentially the same, whereas the other frames are designed to meet major strength requirements. As in the CH-47A KRASH model, several floor frames are lumped together into one element; distribution factors were applied to individual section properties to arrive at the basic element section property. For example, Beam 16-17 is assumed to reflect the sum of the different contributions in bending as follows:

$$\begin{aligned} I_{yy}\,(16\text{-}17) &= 0.25\text{x} \left[I_{yy}\ \text{F.S. } 300 + I_{yy}\ \text{F.S. } 420\right] + \\ &\quad 0.5\ \text{x} \left[I_{yy}\ \text{F.S. } 320 + I_{yy}\ \text{F.S. } 400\right] + \\ &\quad 1.0\ \text{x} \quad I_{yy}\ \text{F.S. } 360 \\ &= 0.25(27.1+43.1)+0.5(43.1+42.2)+37.6 \\ &= 97.8 \text{ in.}^4 \end{aligned}$$

4. External spring element at Node 10.



Cross Section of Typical Intermediate Floor Frame

The spring characteristics are based on using the compression capability of the frame web.

Core: 3 pcf 20 N 3003 Cell Size = 3/8 in.

$$G_{xz} = 4.8 \times 10^3 \text{ lb/in.}^2$$

$$G_{yz} = 12.8 \times 10^3 \text{ lb/in.}^2$$

Web: $t_1 = t_2 = 0.02$ in.

$b = 9.2$ in. $= a$ (Assumed)

$d = 0.25$ in.

$h = 0.29$ in.

Analysis (see Reference 32 for methodology):

$$K = 6$$

$$K_c = \frac{1}{24}\left[4\ G_{yz} + 3\ G_{xz}\left(a/b\right)^2\right]$$

$$= \frac{1}{24}\left[4 \times 12.8 + 3 \times 4.8\right] = 2.74$$

$$\frac{2hK_c}{(t_1+t_2)} = \left[\frac{2 \times .29 \times 2.74 \times 10^3}{.04}\right] = 3.97 \times 10^4$$

$$\frac{b}{d\sqrt{K}}\ \frac{t_1+t_2}{2\sqrt{t_1 t_2}} = \frac{9.2}{.25\sqrt{6}}\left[\frac{.04}{2\sqrt{.02 \times .02}}\right]$$

$$= 15.02$$

$$\therefore\ F_c = 60{,}380 \text{ psi for 7075-T6 clad}$$

Using a dynamic amplification factor of 1.15 and ratioing for 7075-T6 bare

$$F_c = 60380 \times \frac{67000}{62000} \times 1.15 = 75037 \text{ psi}$$

P' = Equivalent strength at yield $= 75037 \times .04$

$= 3{,}001$ lb per inch width

32. STRESS MANUAL, Boeing document D6-22695, Boeing Commercial Airplane Company, Seattle, Washington, December 1971.

Effective strength at yield for spring at 10.

= Sum of contributions from floor frames at Stations 160, 180, 220, 240, 260, 280, and 300.

$$= 0.25\left(P_{160}+P_{220}+P_{300}\right)+0.5\left(P_{180}+P_{280}\right)$$

$$+P_{240}+P_{260}$$

$\simeq$ 2.75 P' per inch width

$\therefore$ Yield strength for effective width assumed 20 in.

$= 20 \text{x} 2.75 \text{x} 3001$

$= 1.65 \text{x} 10^5$ lb (1)

Effective strain = .0076

$\therefore \Delta 1 = .0076 \text{x} 10.4 = 0.079$ in. (2)

Assume residual strength at collapse of web = 10% of yield strength and associated change in length = 6 in. (3)

Assuming uniformly distributed load on the floor frames.

$$K_1 = \frac{48EI}{1^3}$$

For three equal springs in series K(spring) = $3K_1$

Use I_{eff} = 36.8 in.^{4}

1 = 97.6 in.

E = $10 \text{x} 10^6$ lb/in.^{2}

adjacent frame contribution factor = 2.75

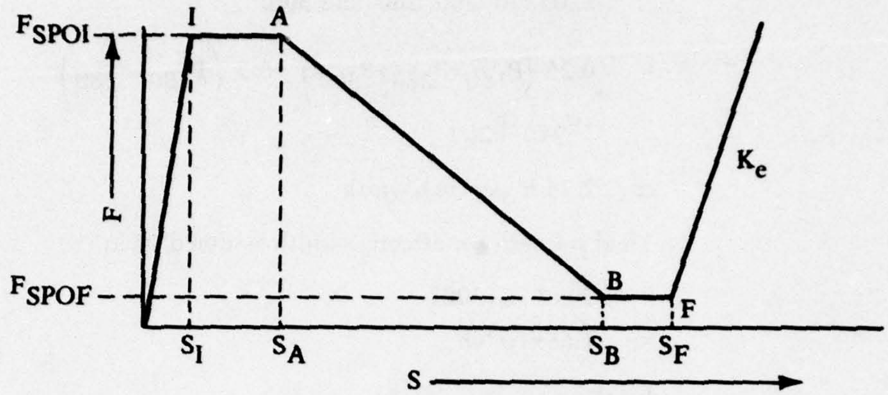
$\therefore$ Effective K at bottoming

$= K_e$

$$= \frac{48 \text{x} 10 \text{x} 10^6 \text{x} 36.8}{97.6^3} \text{x} 3 \text{x} 2.75$$

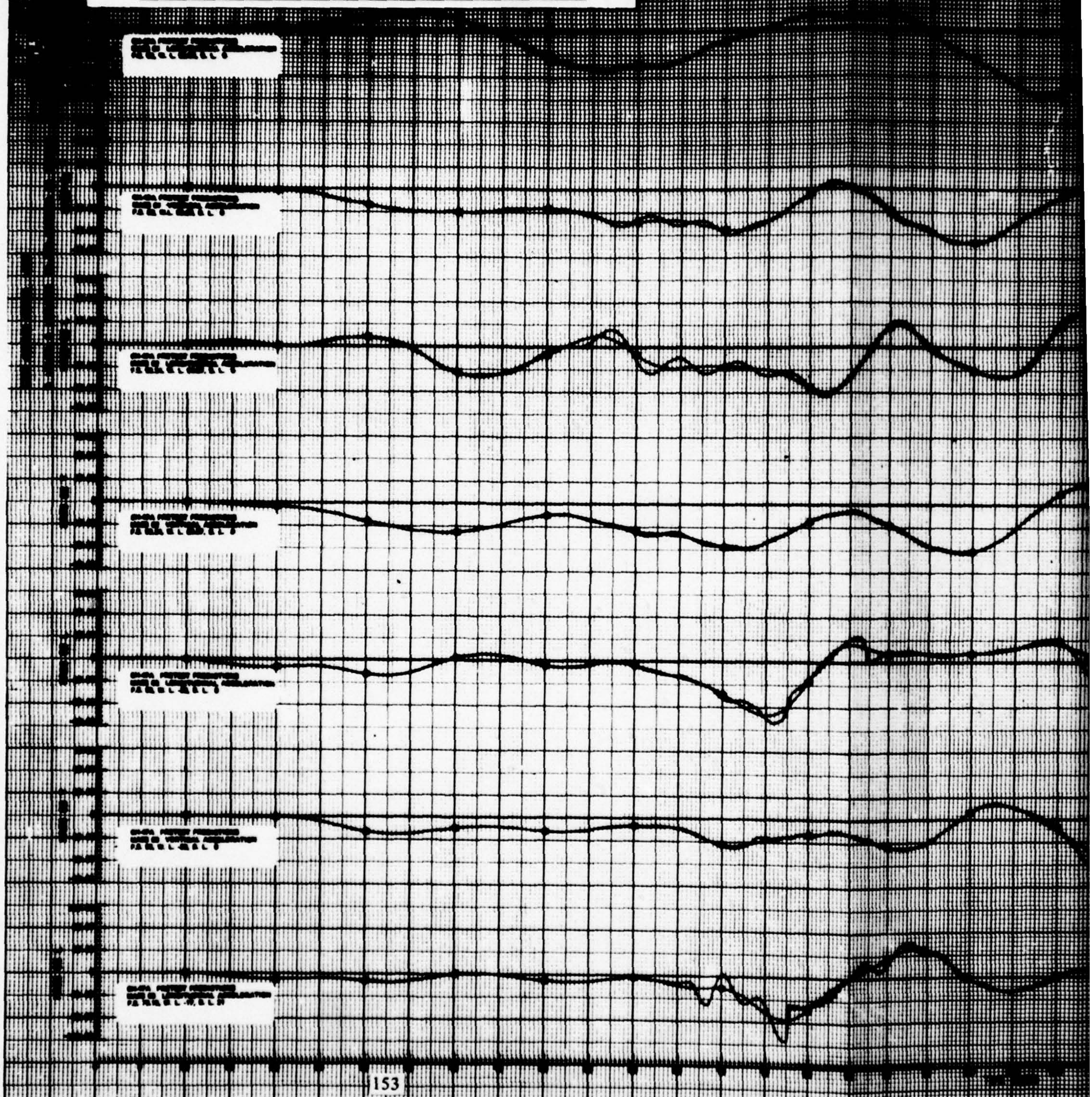
$= 1.5675 \text{x} 10^5$ lb/in. (4)

The values obtained above were used to define the spring characteristic shown below:



L	= 7 in.		S_I	= 0.079 in.		S_F	= 6 in.
μ	= 0.3		S_A	= 0.1 in.		F_{SPOI}	= 1.65083×10^5
K_e	= 1.5675×10^5		S_B	= 5.9 in.		F_{SPOF}	= 1.65083×10^4

APPENDIX B
CH-47A (KRASH) PRETEST MODEL – ACCELERATIONS AT SELECTED MASS POINTS (100 Hz FILTERED)



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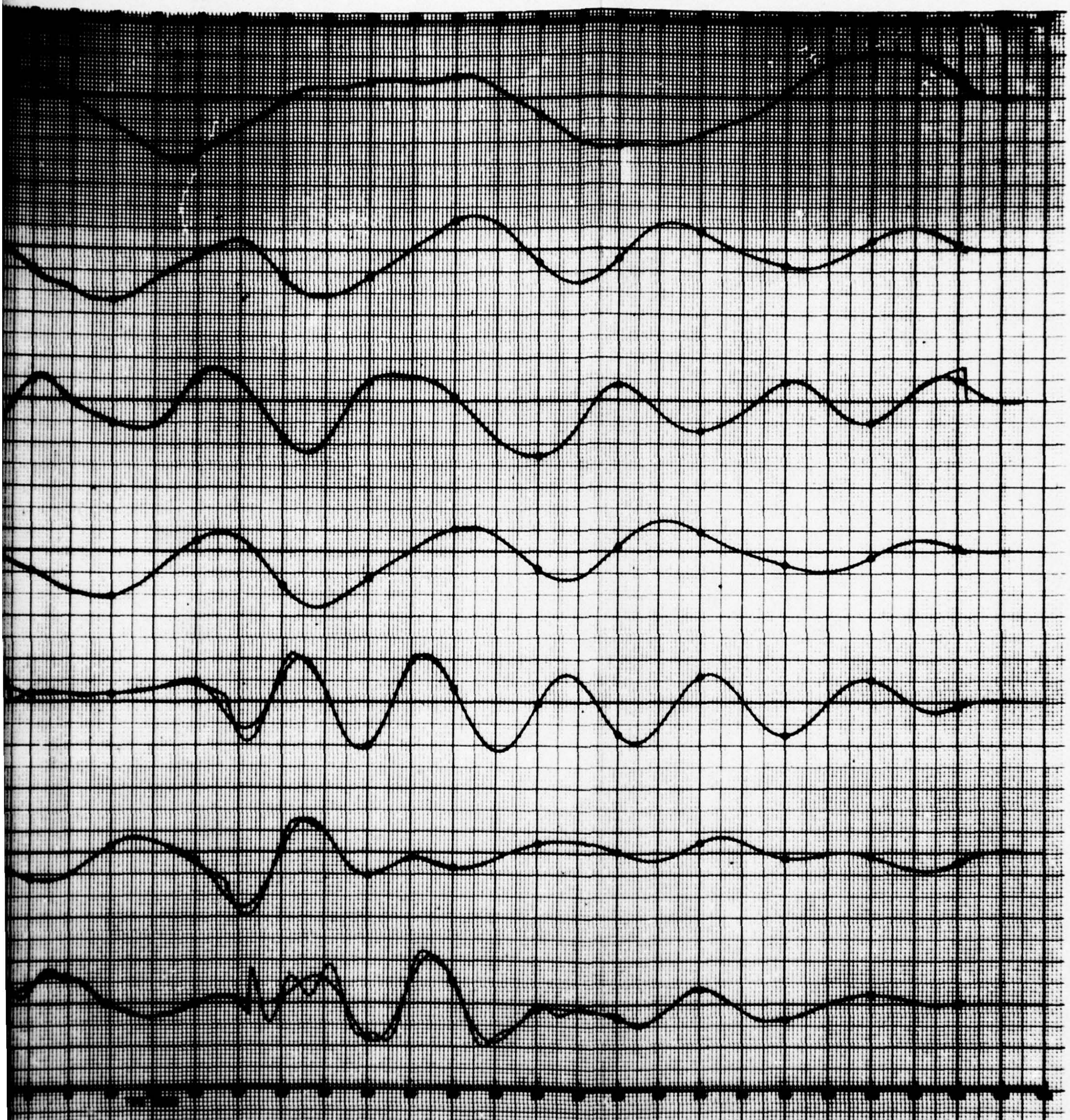

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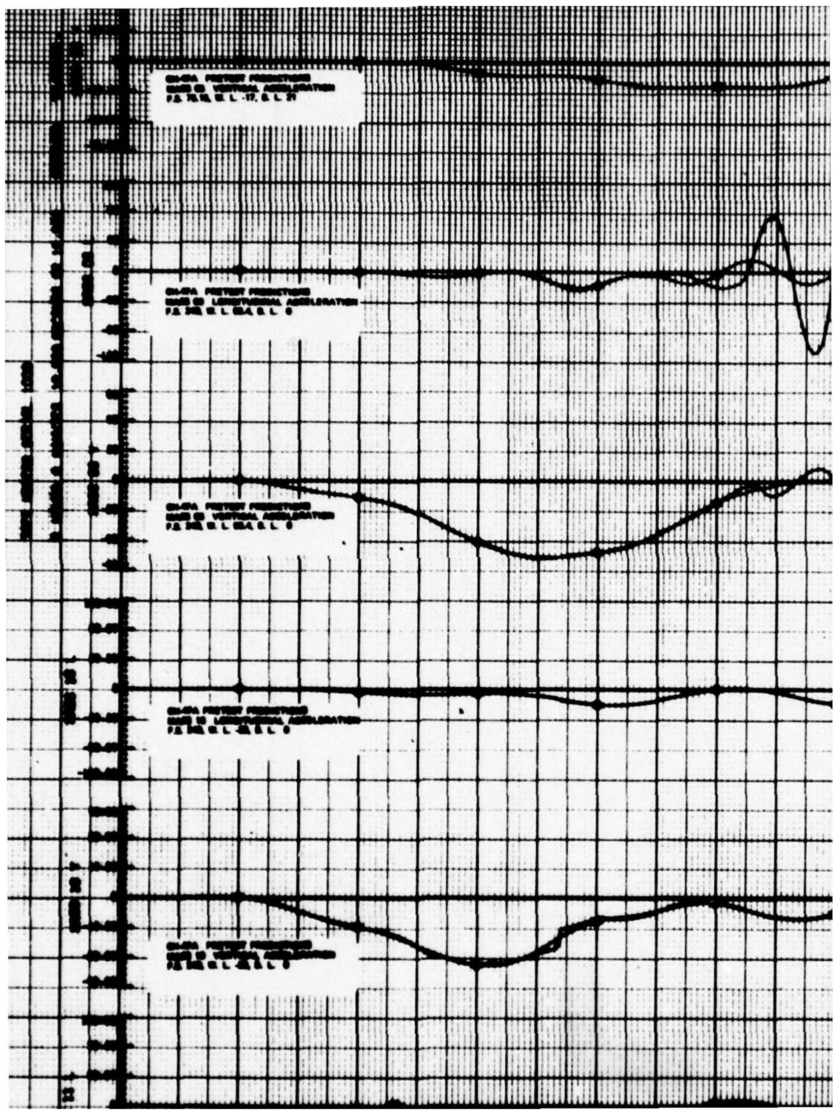

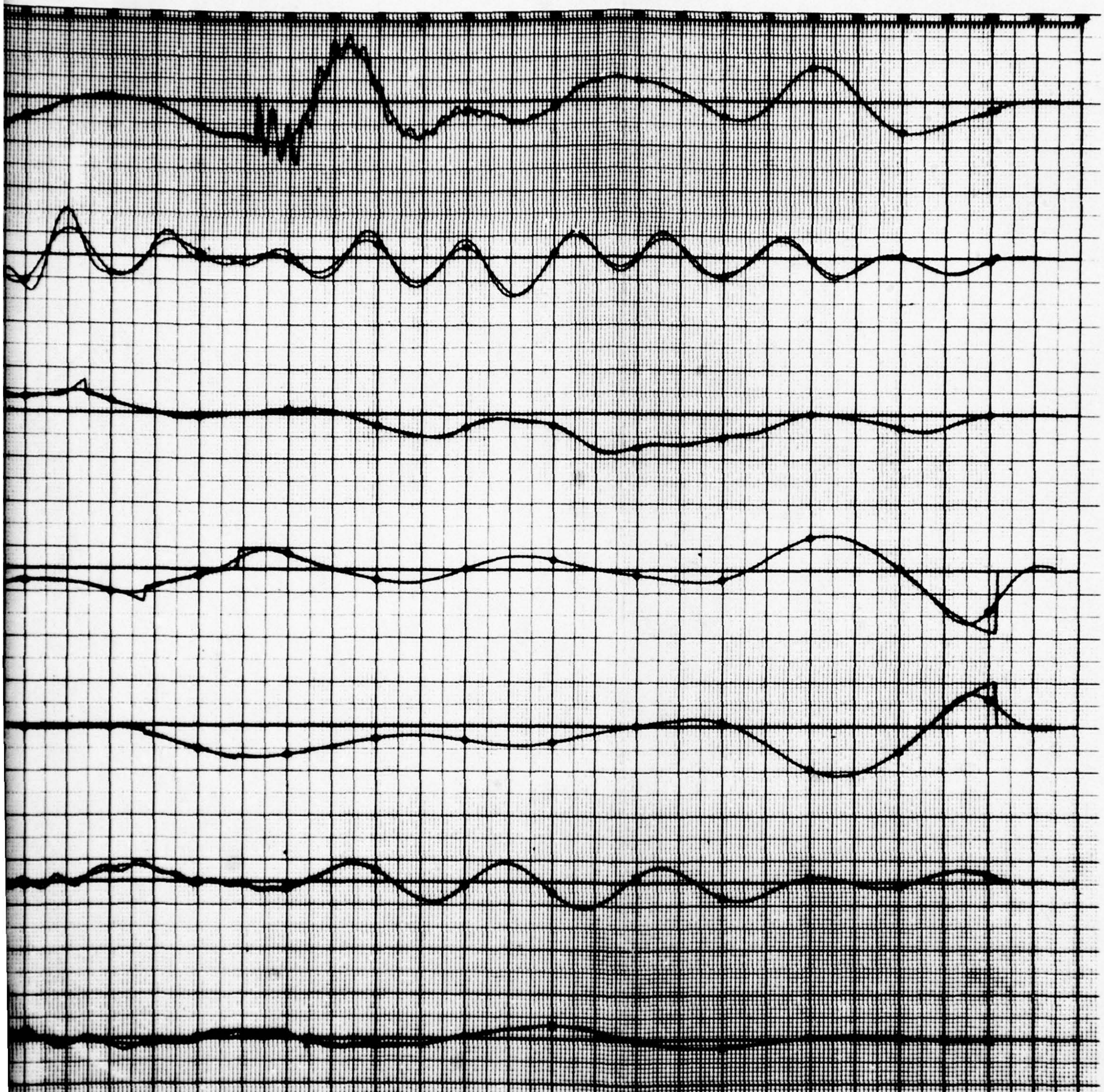

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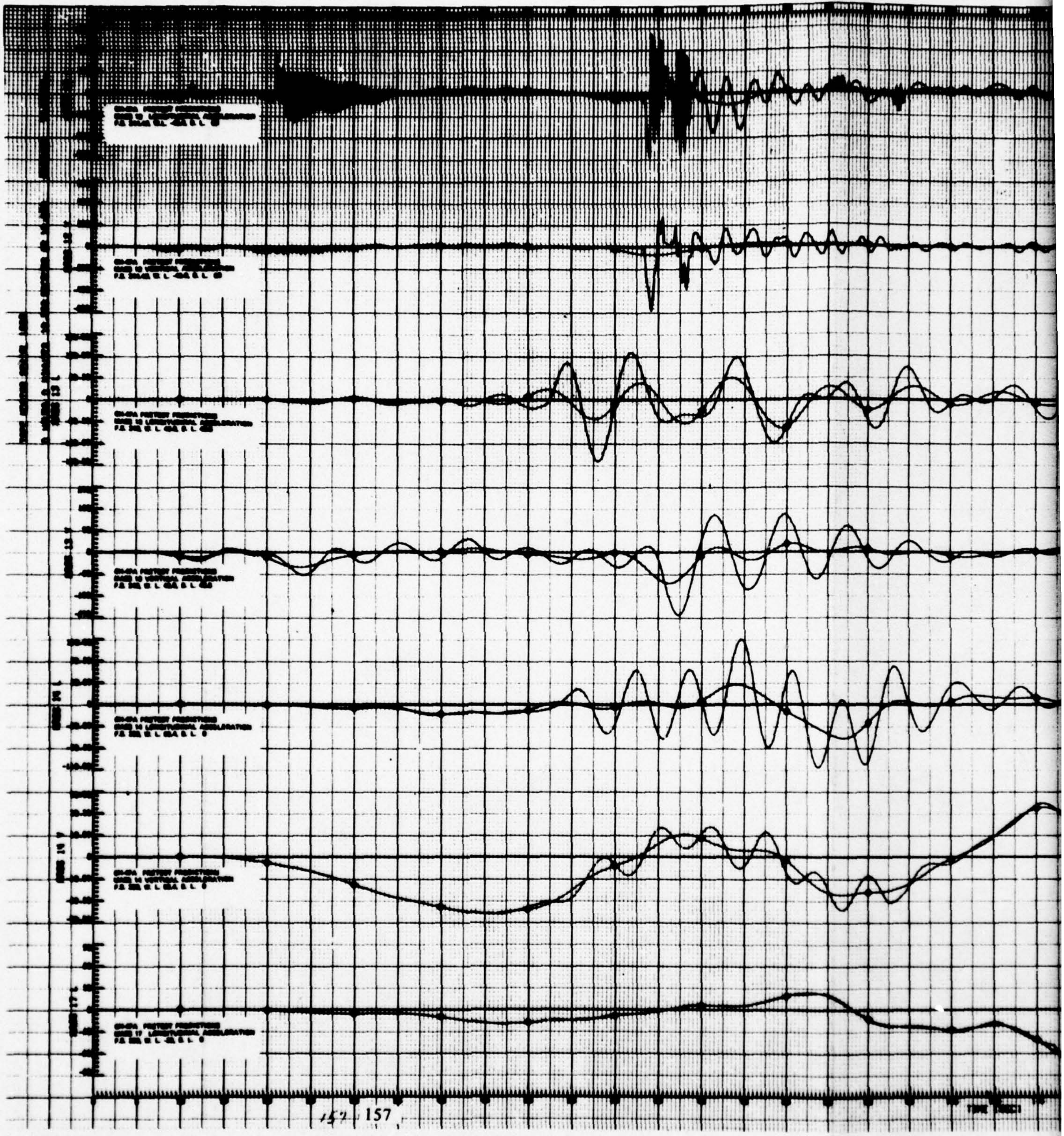
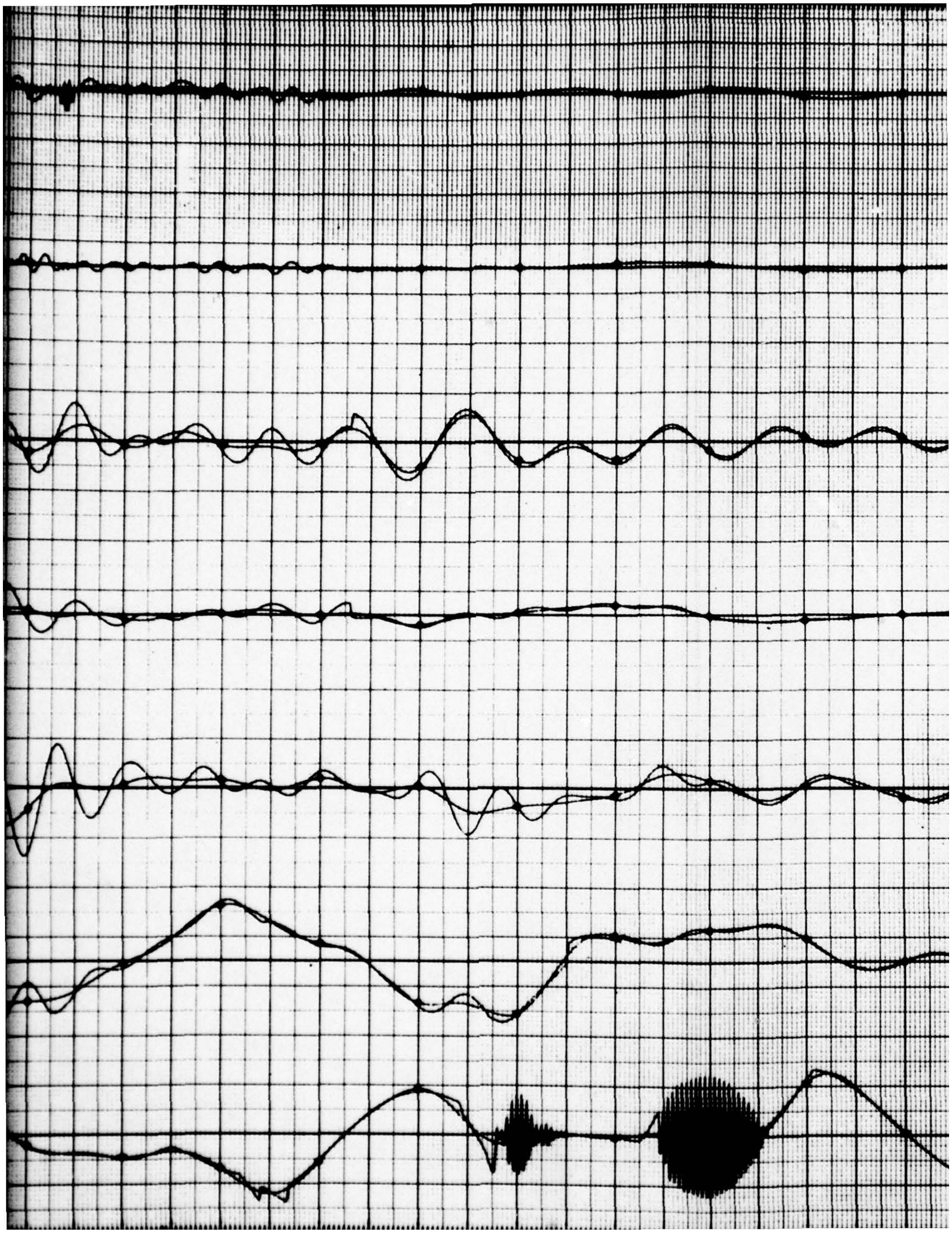
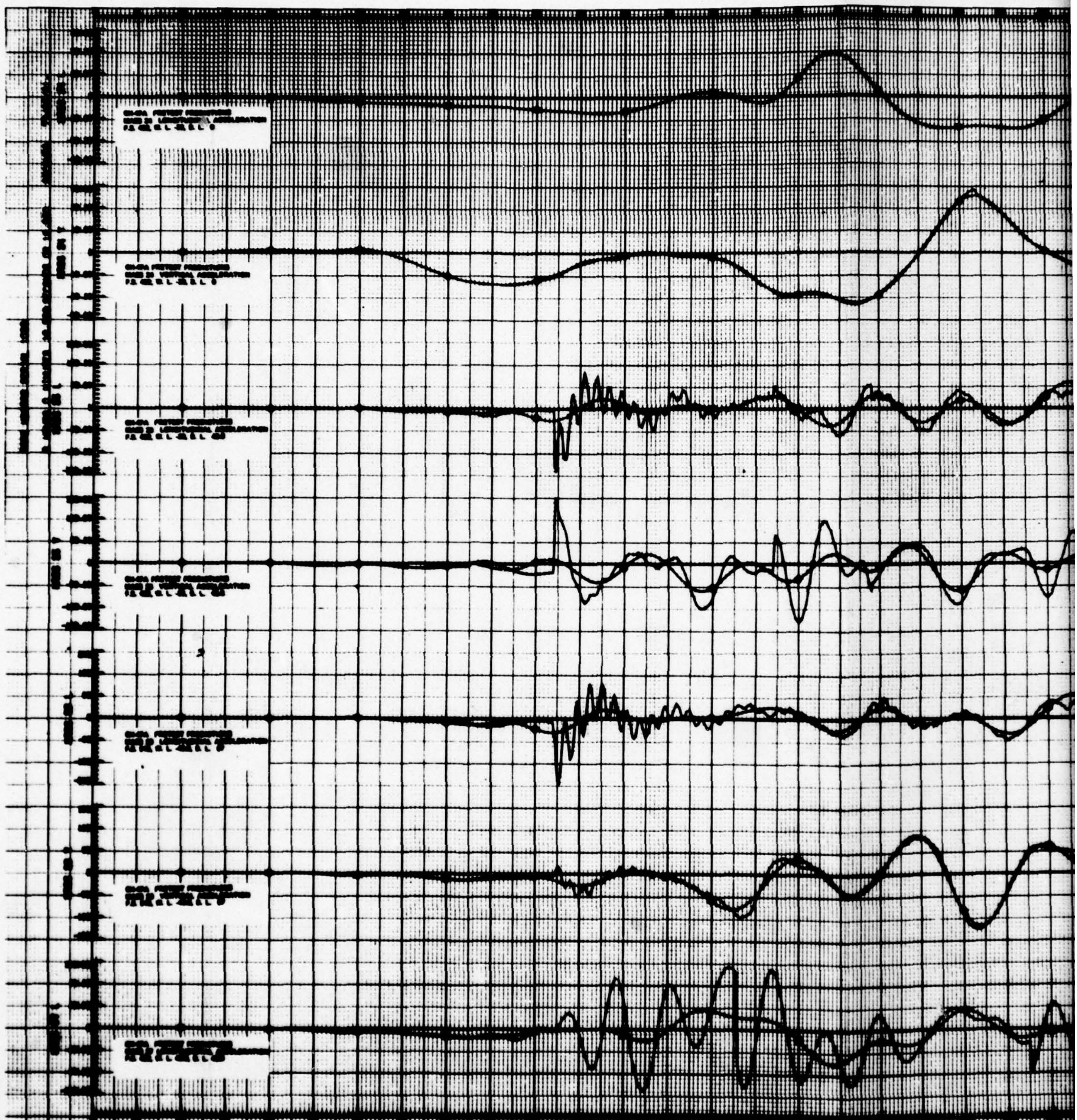
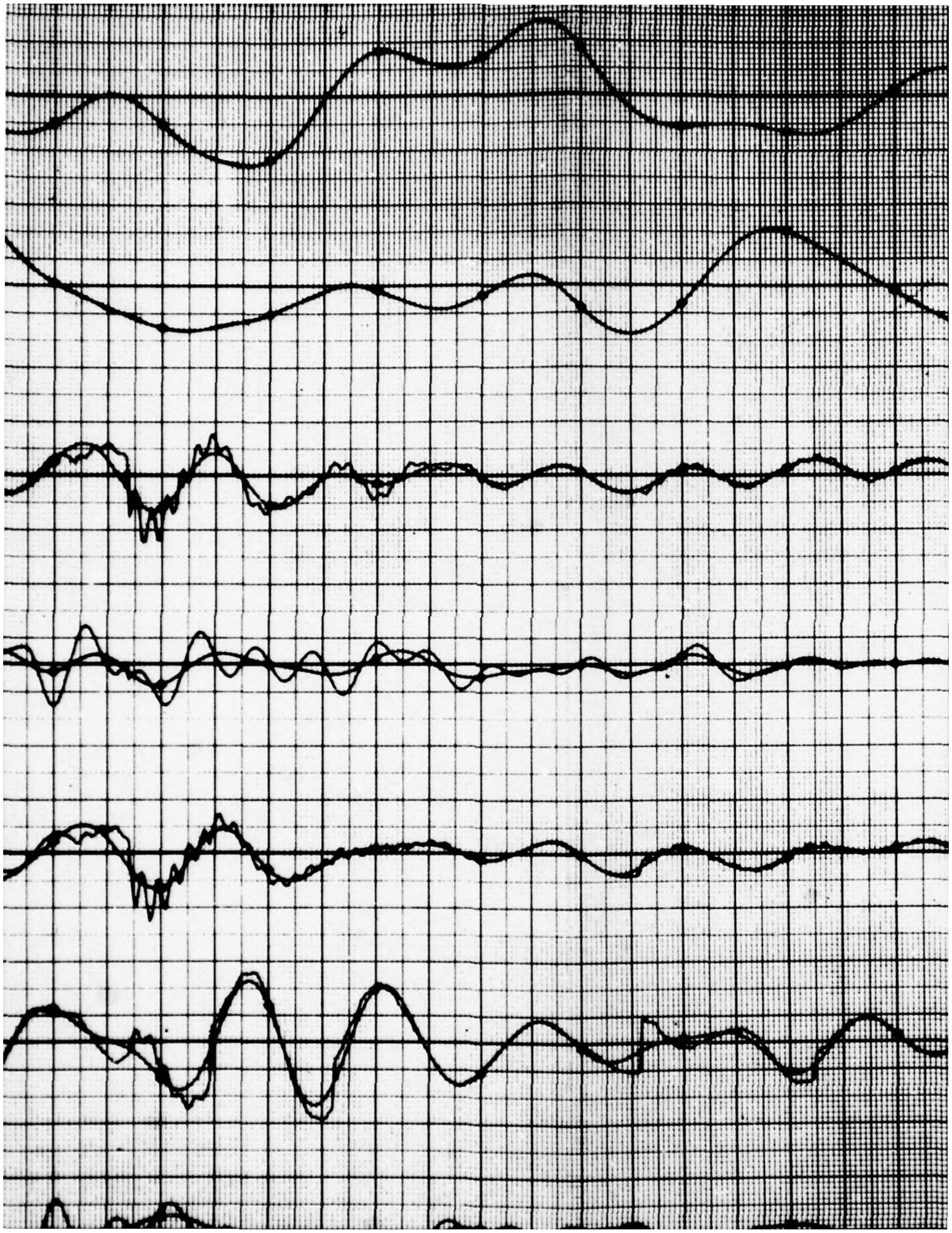
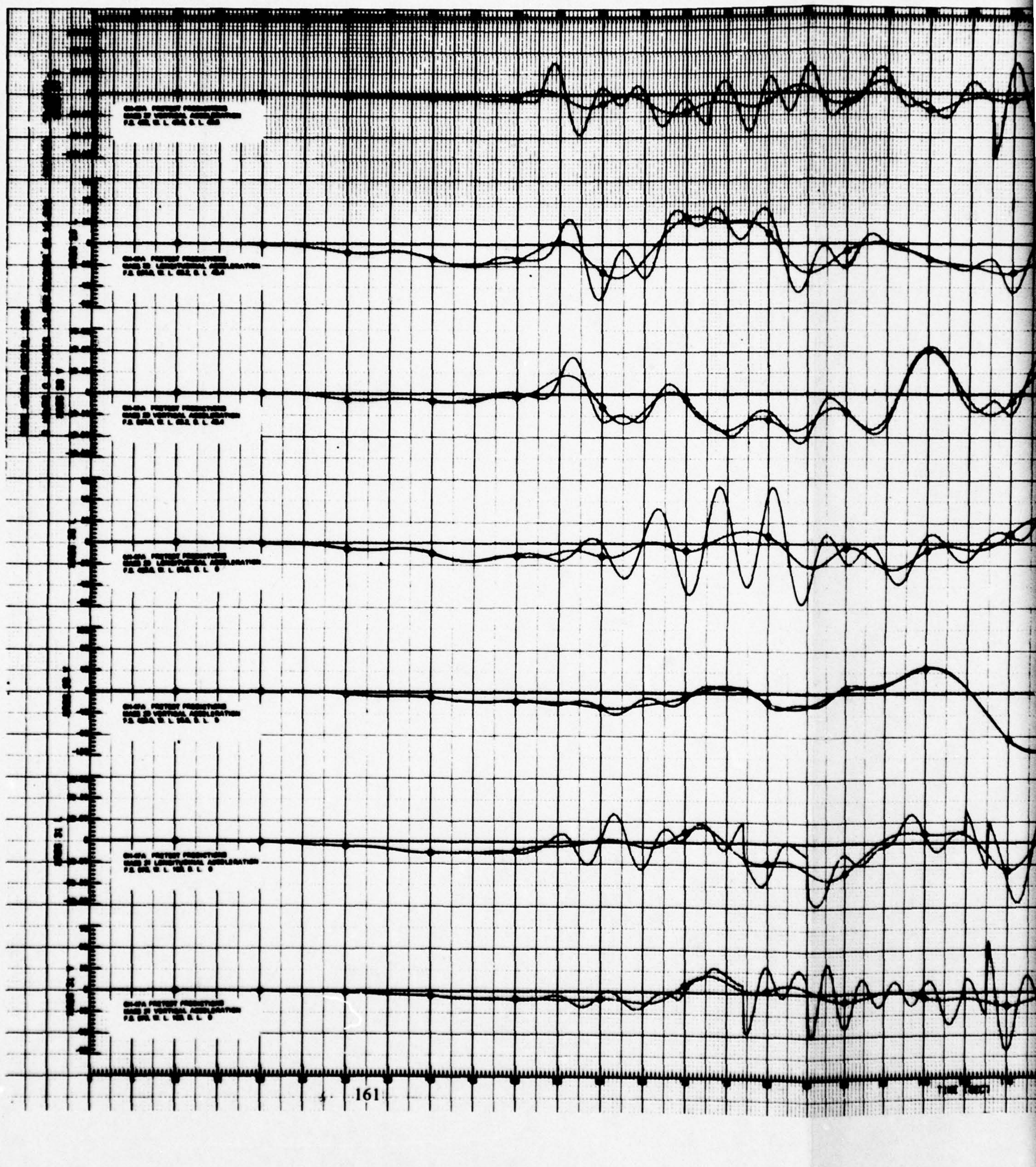
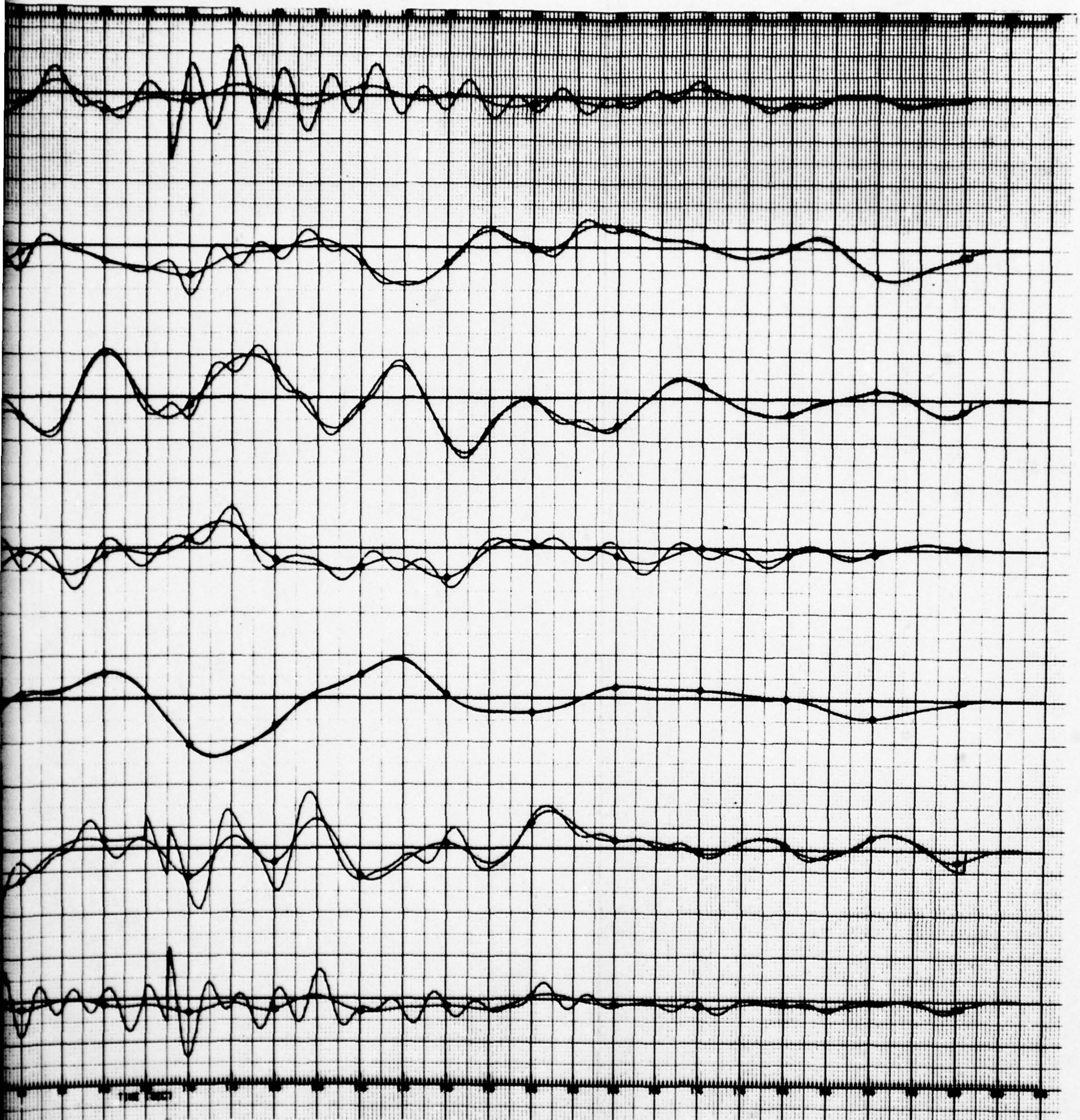


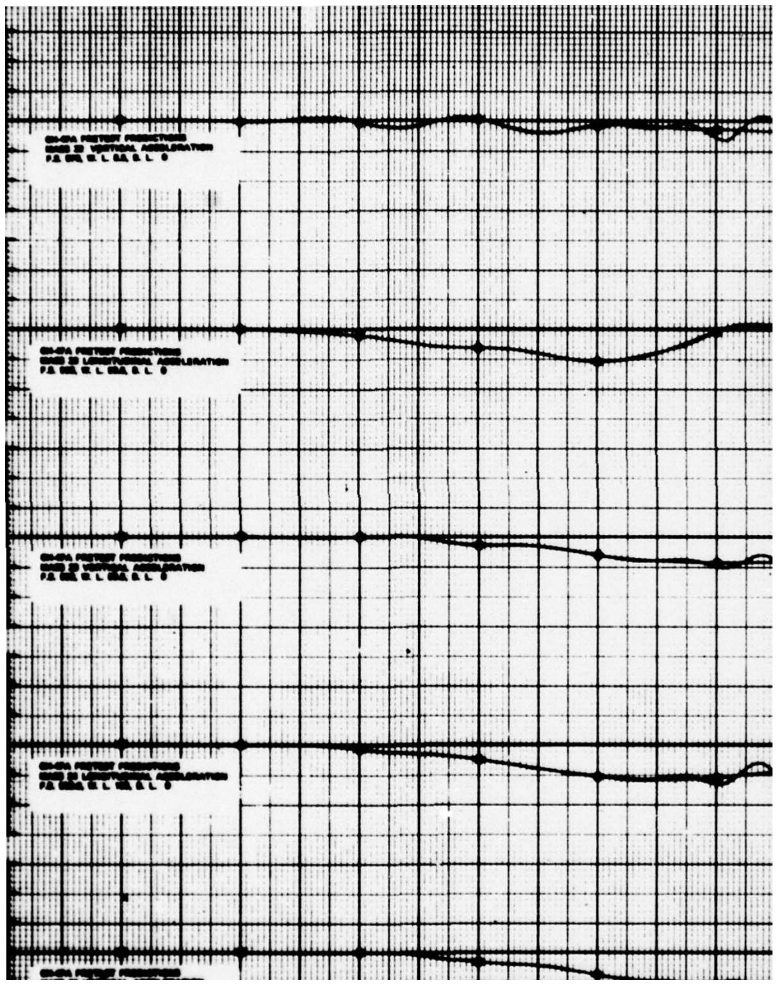


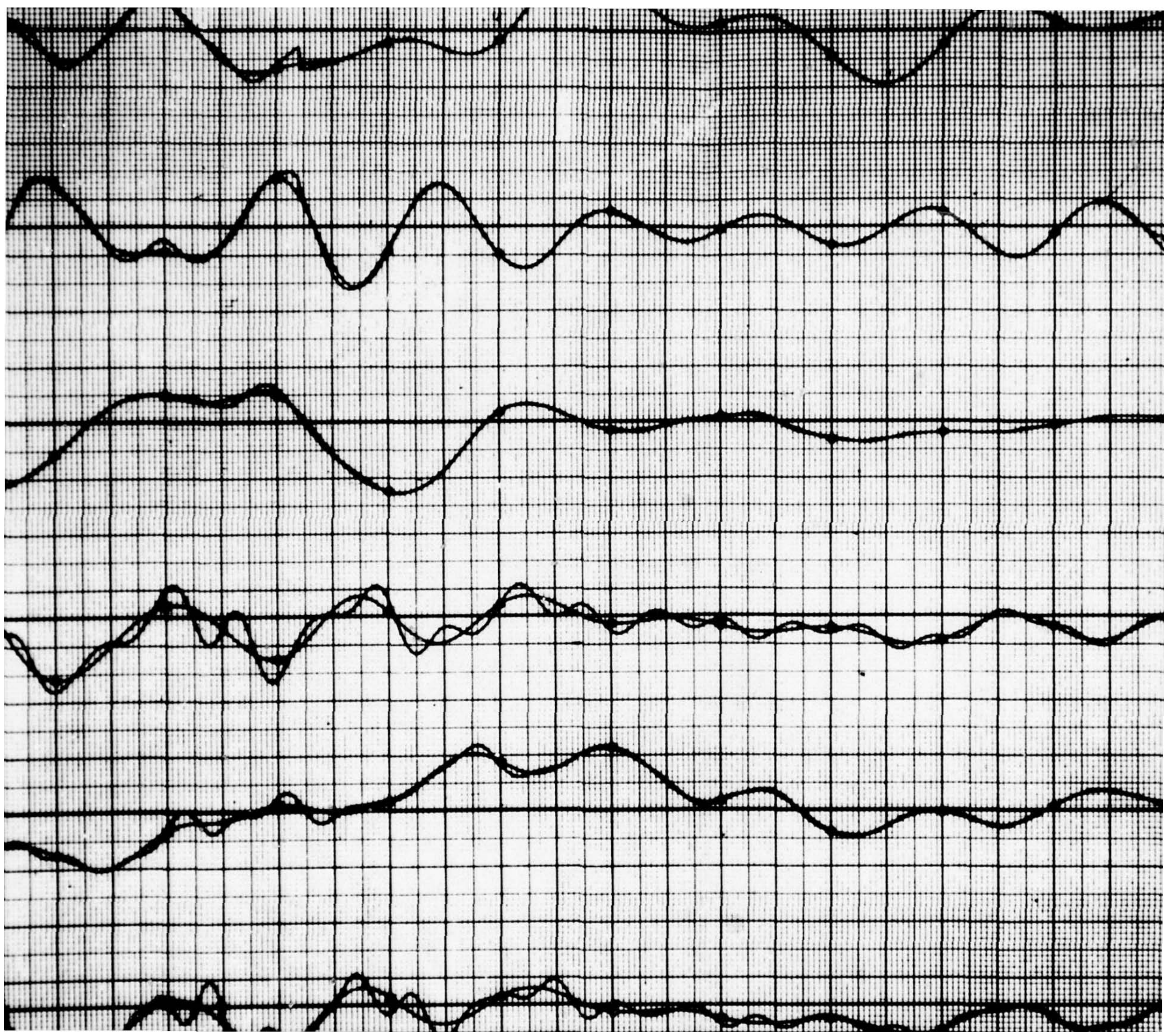




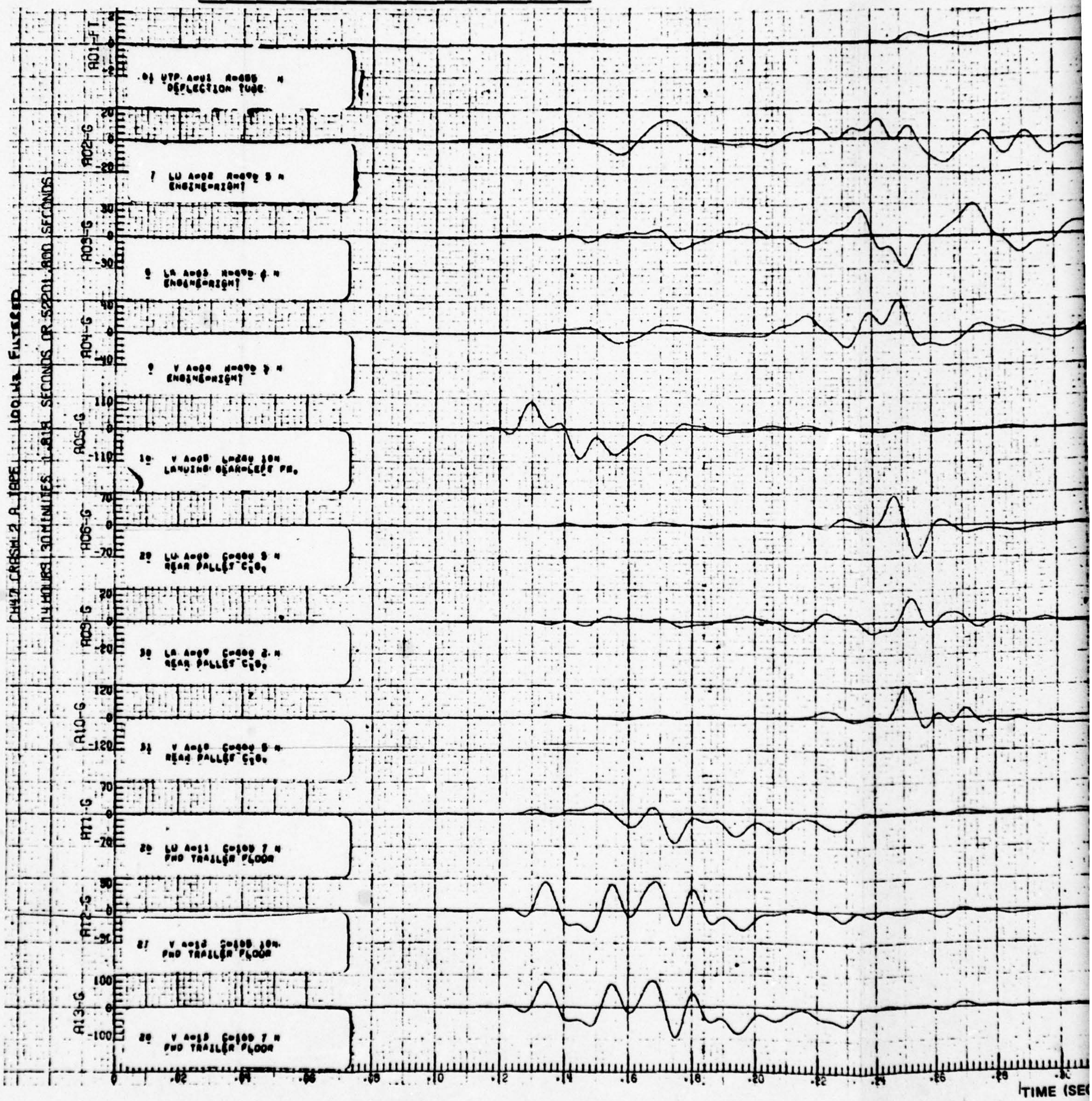








APPENDIX C
CH-47A CRASH IMPACT TEST (T-40)
ACCELERATION DATA (100 Hz FILTERED)



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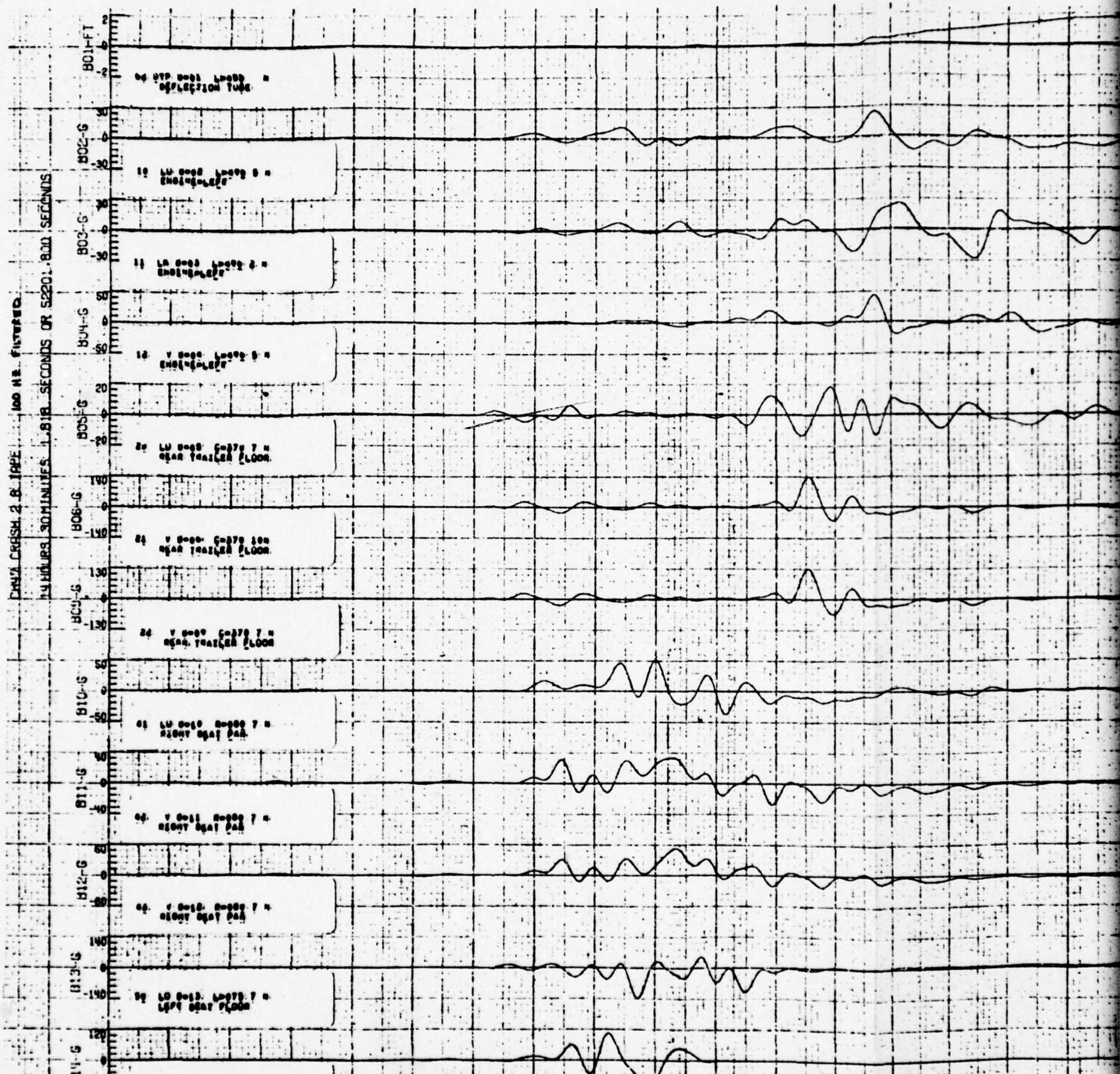
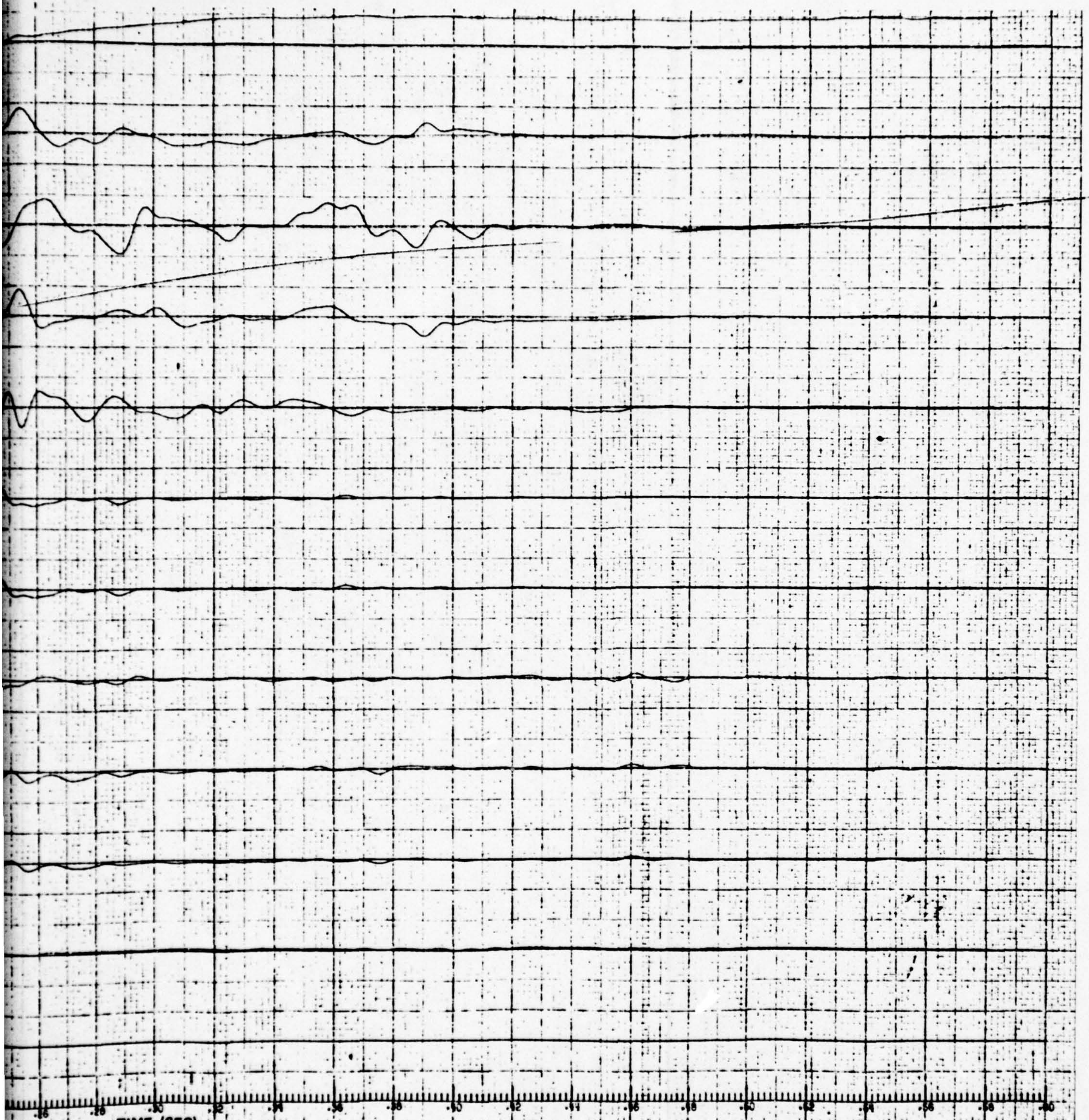

B01-FT
B02-G
B03-G
B06-G
B10-G
DEFLECTION TUBE
REAR TRAILER FLOOR
RIGHT SEAT PAN
LEFT SEAT FLOOR
TIME (SEC)



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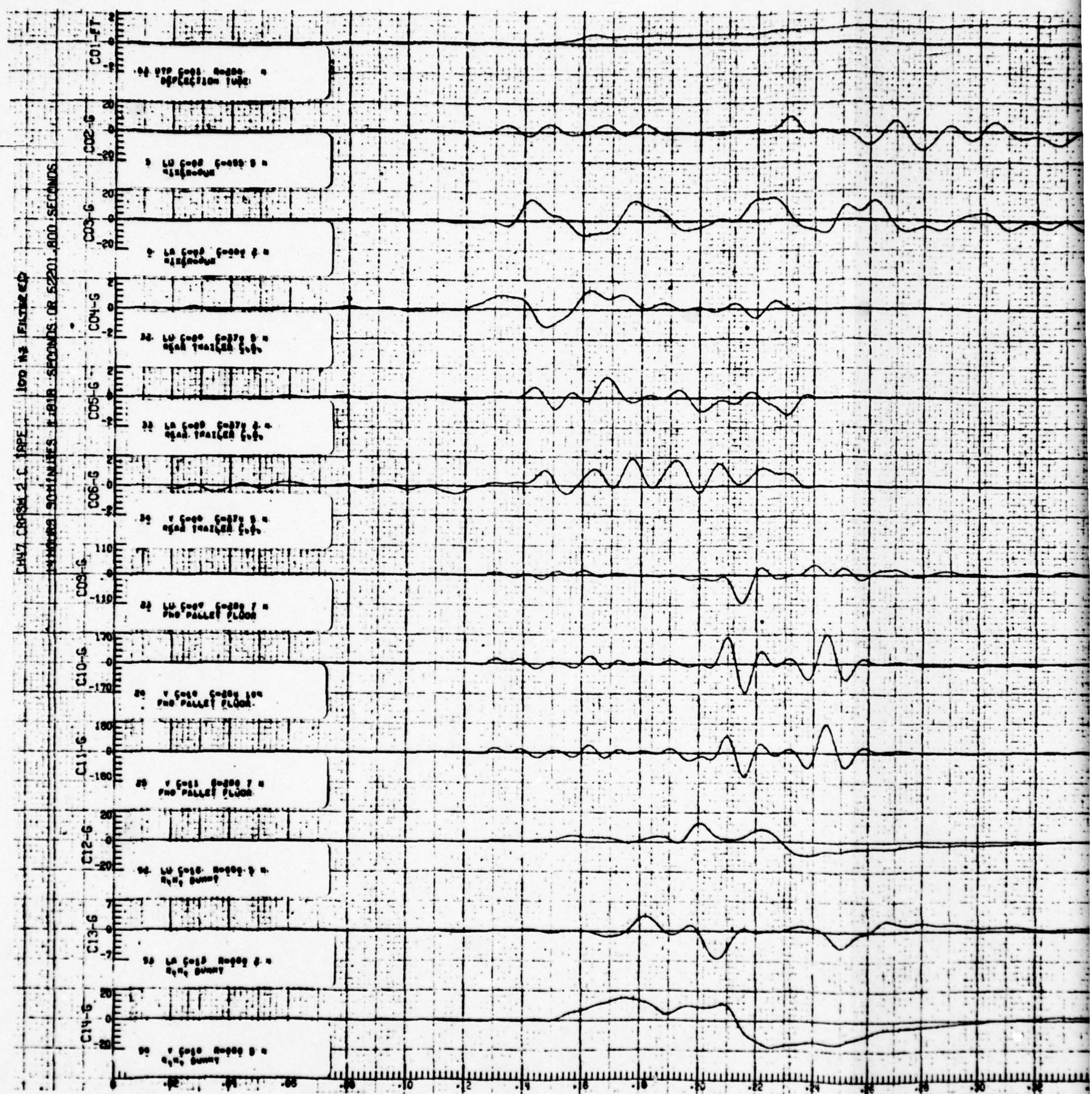
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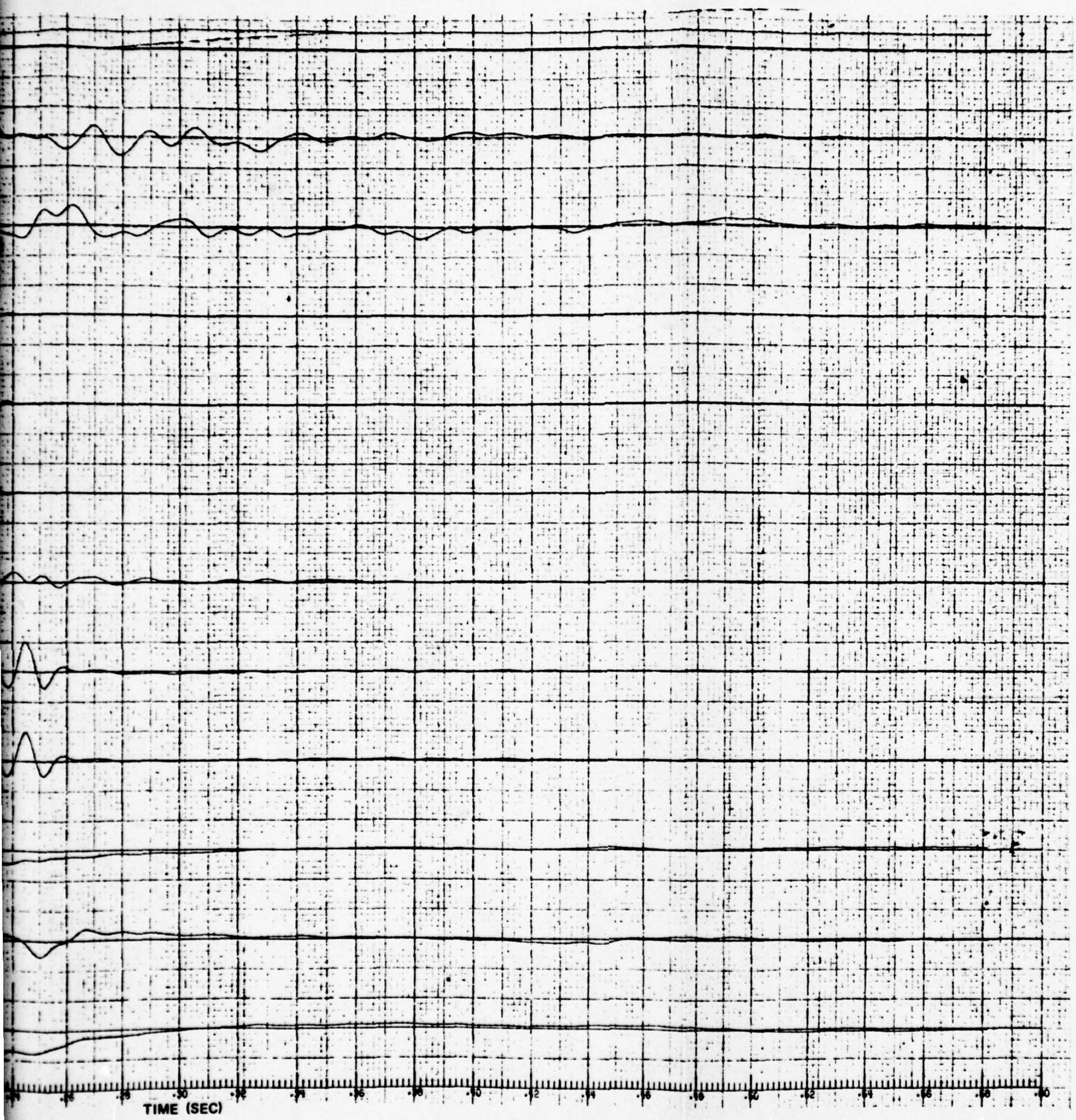

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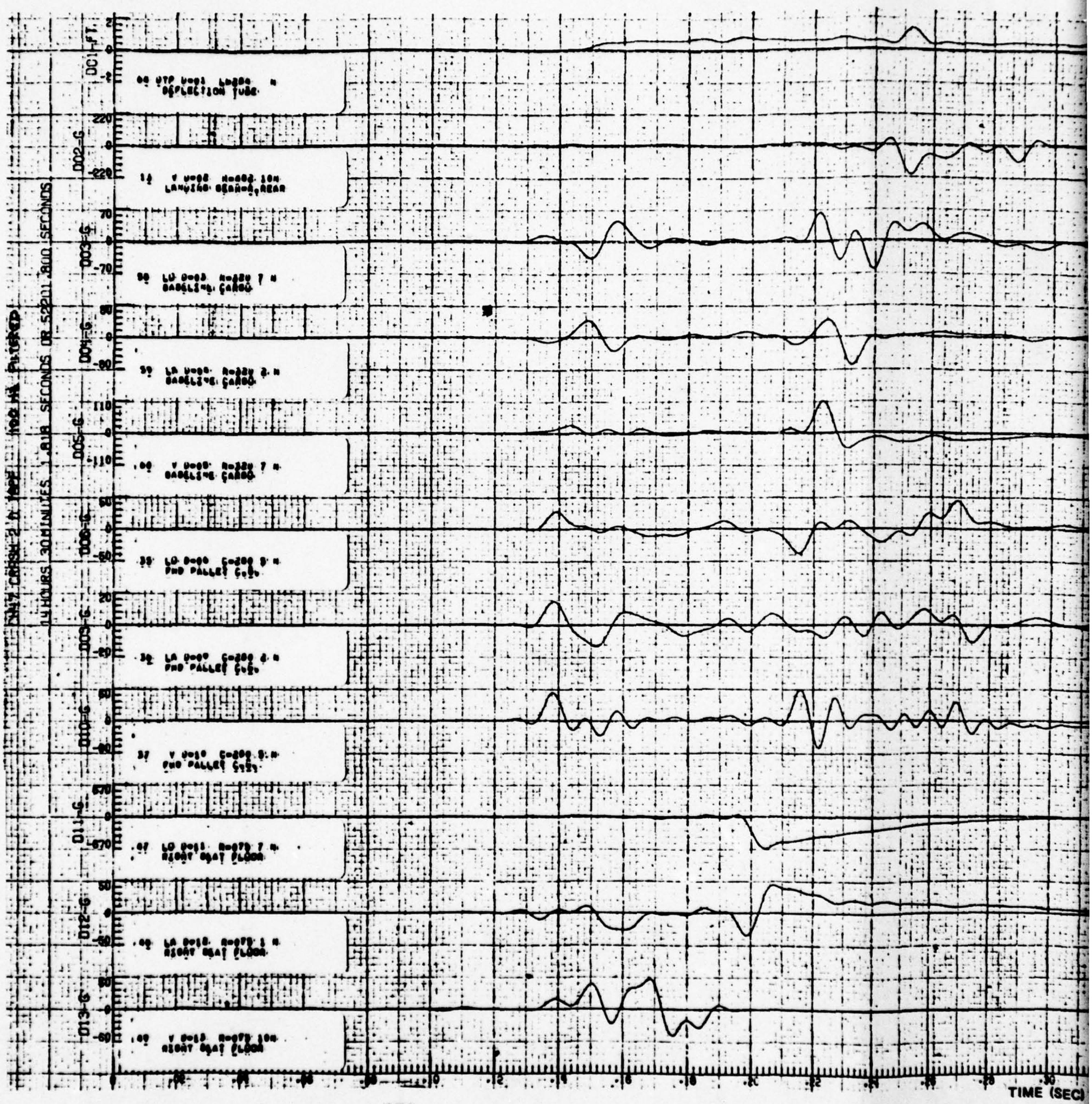
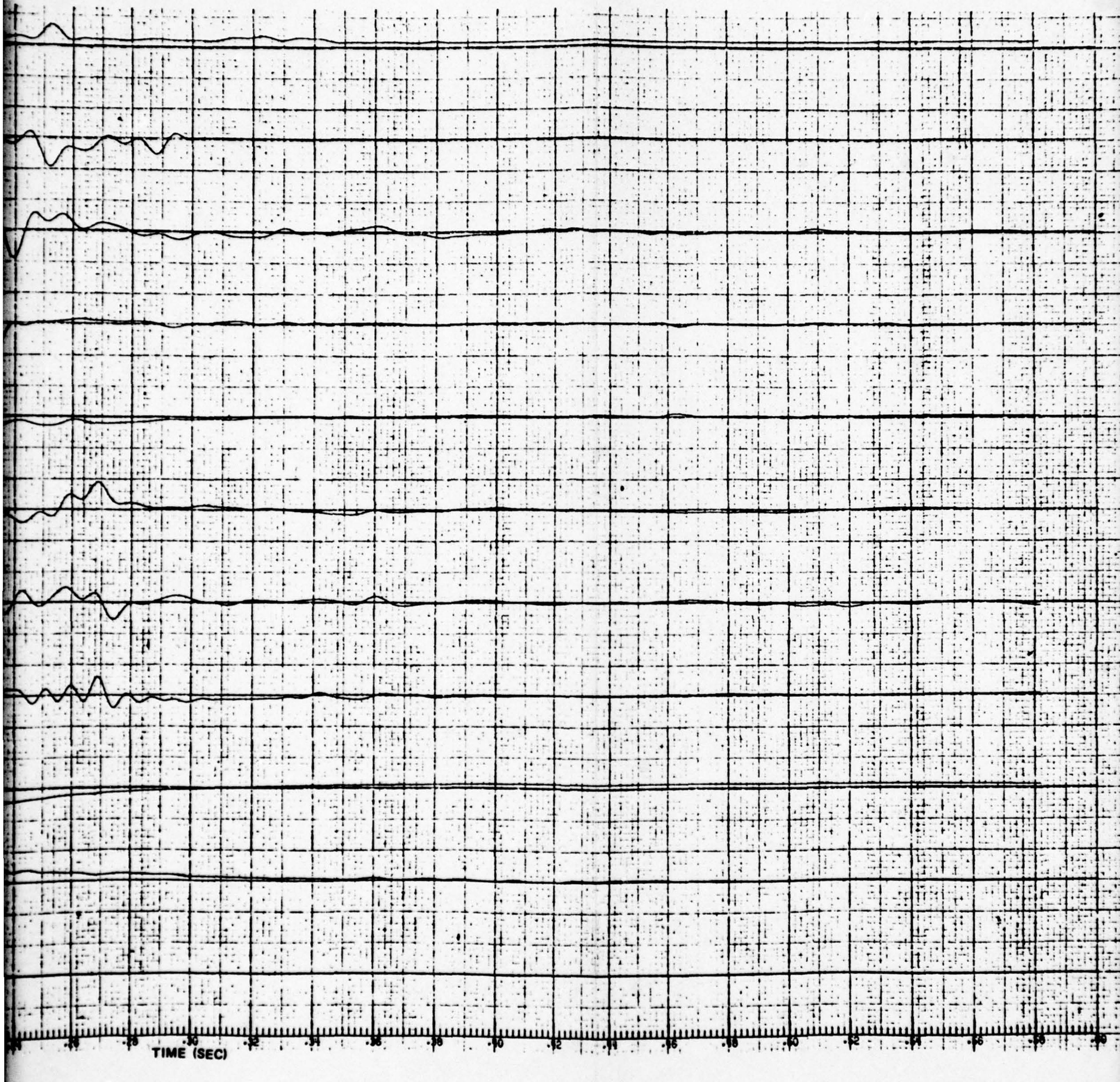
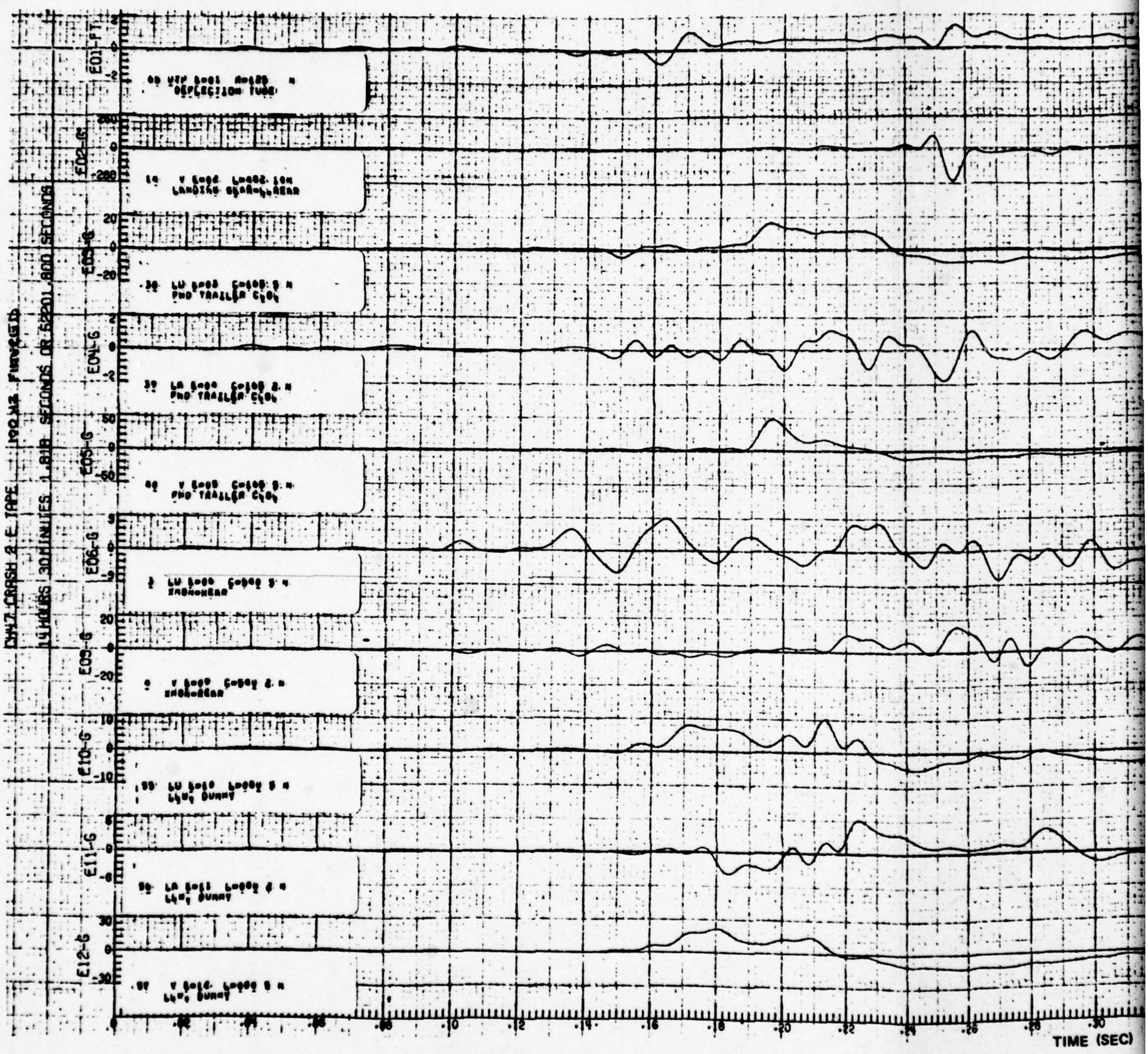


TIME (SEC)



2



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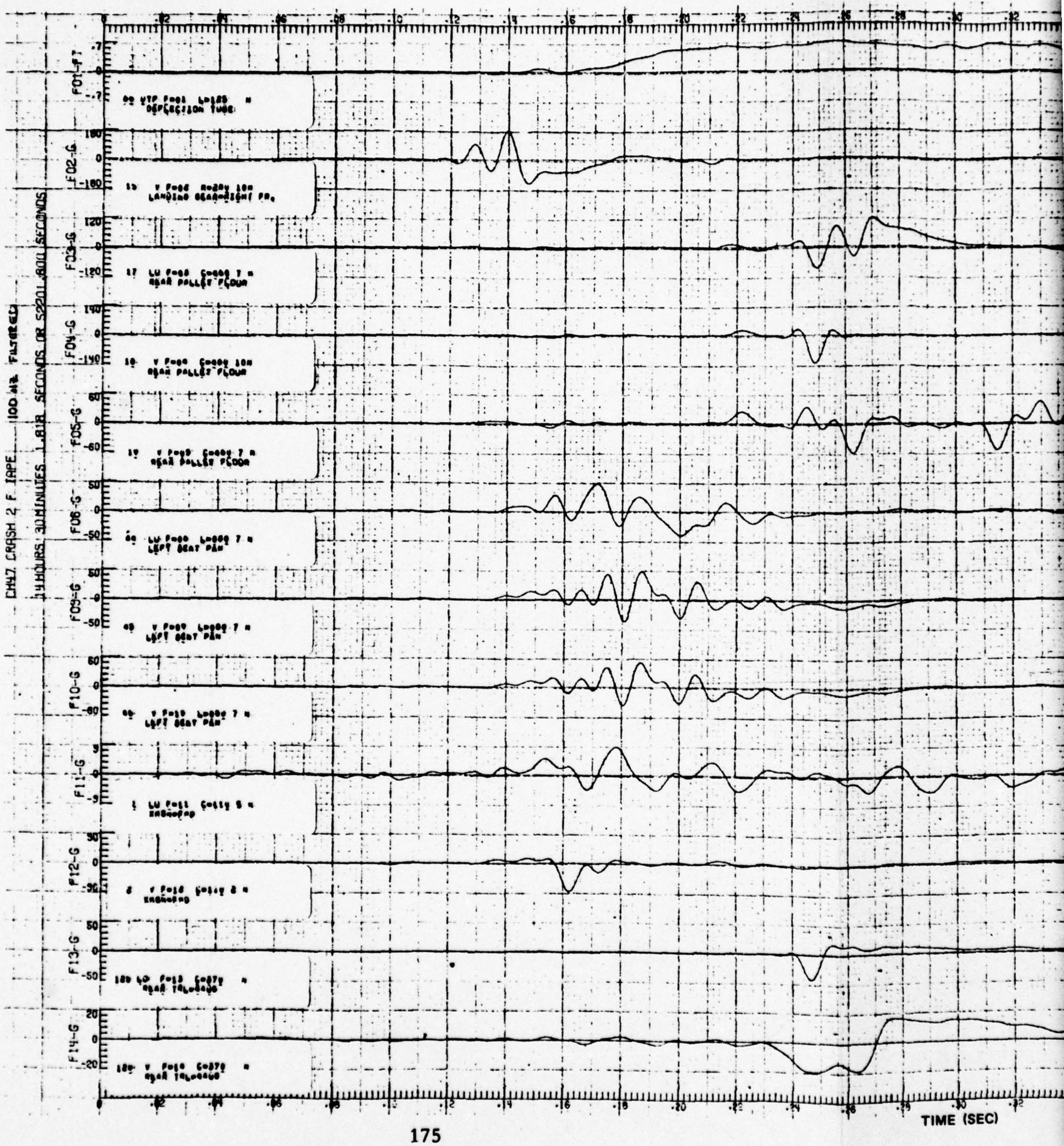
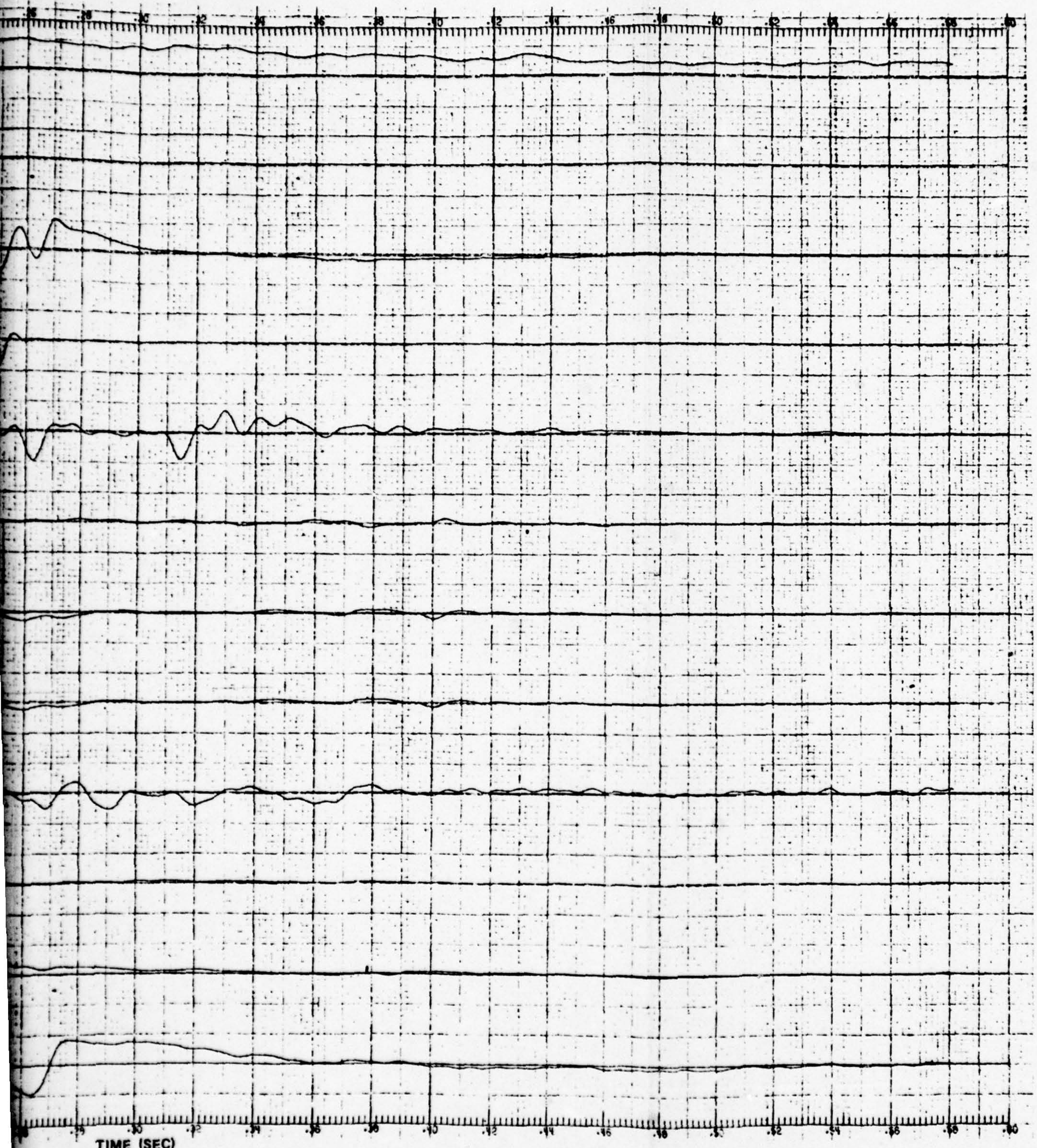
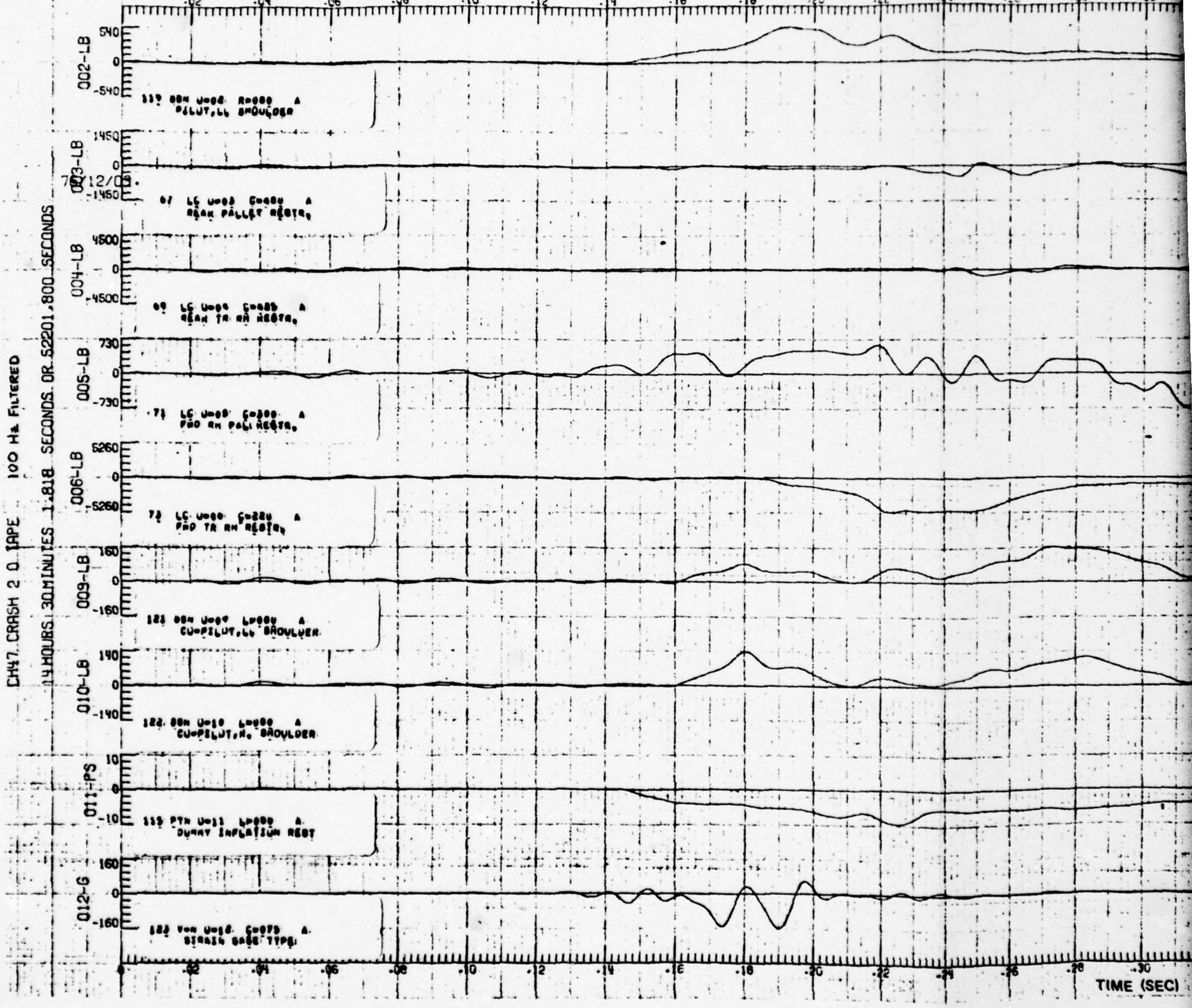
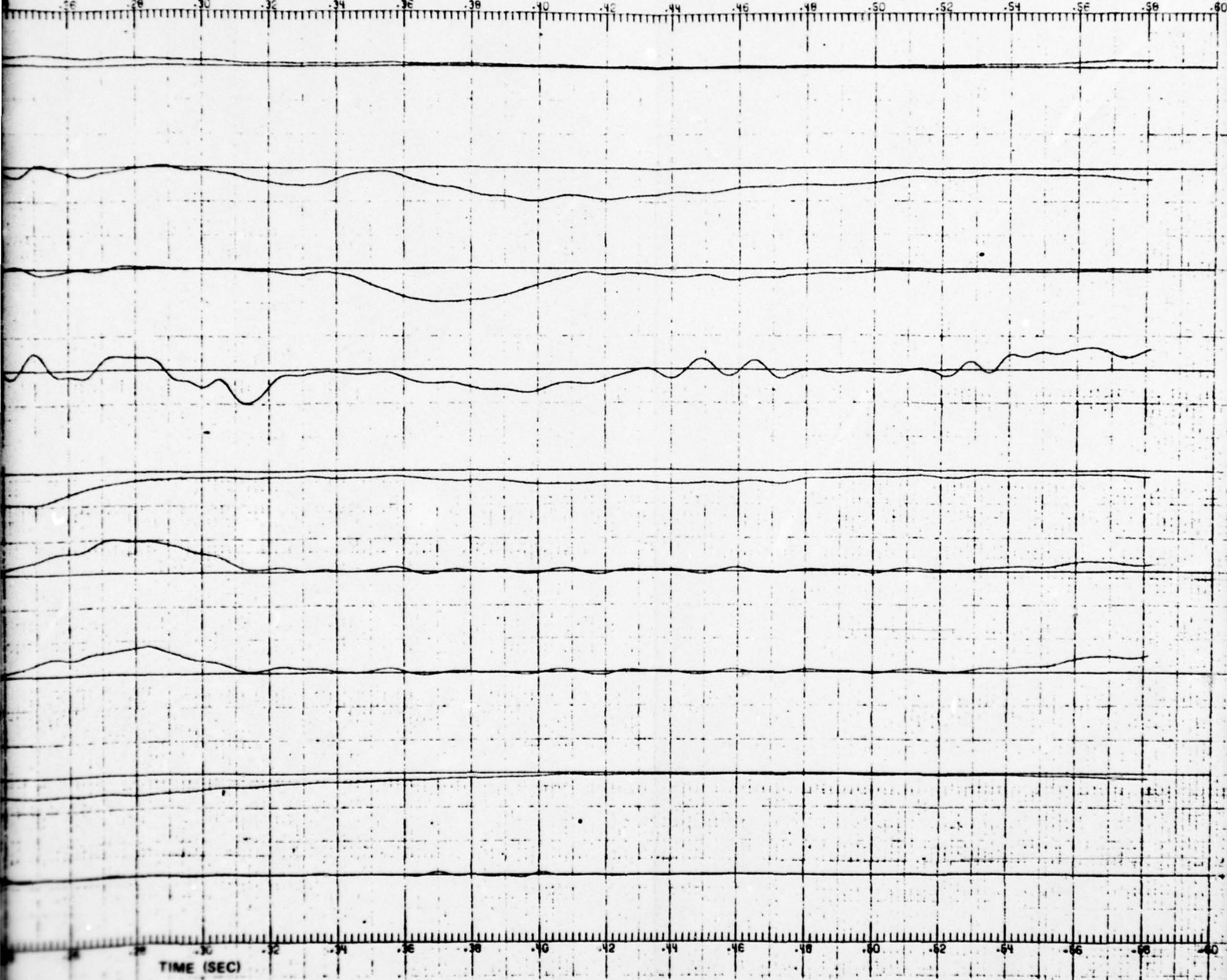

CH47 CRASH 2 F TAPE 100 HZ FILTERED
14 HOURS 30 MINUTES 1.818 SECONDS OR 52201.804 SECONDS
F01-FT
F02-G
F03-G
F04-G
F05-G
F06-G
F09-G
F10-G
F11-G
F12-G
F13-G
F14-G
TIME (SEC)

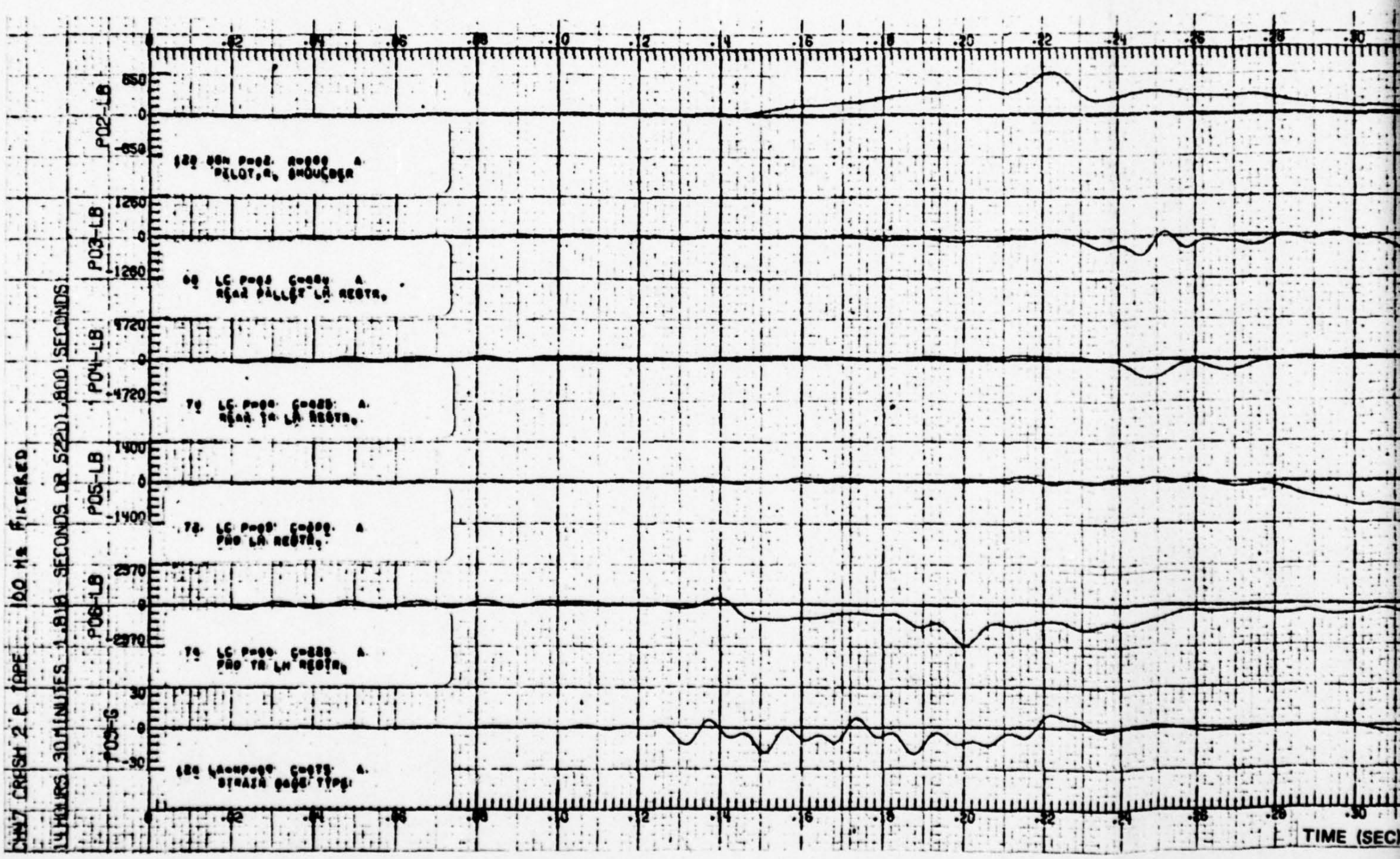


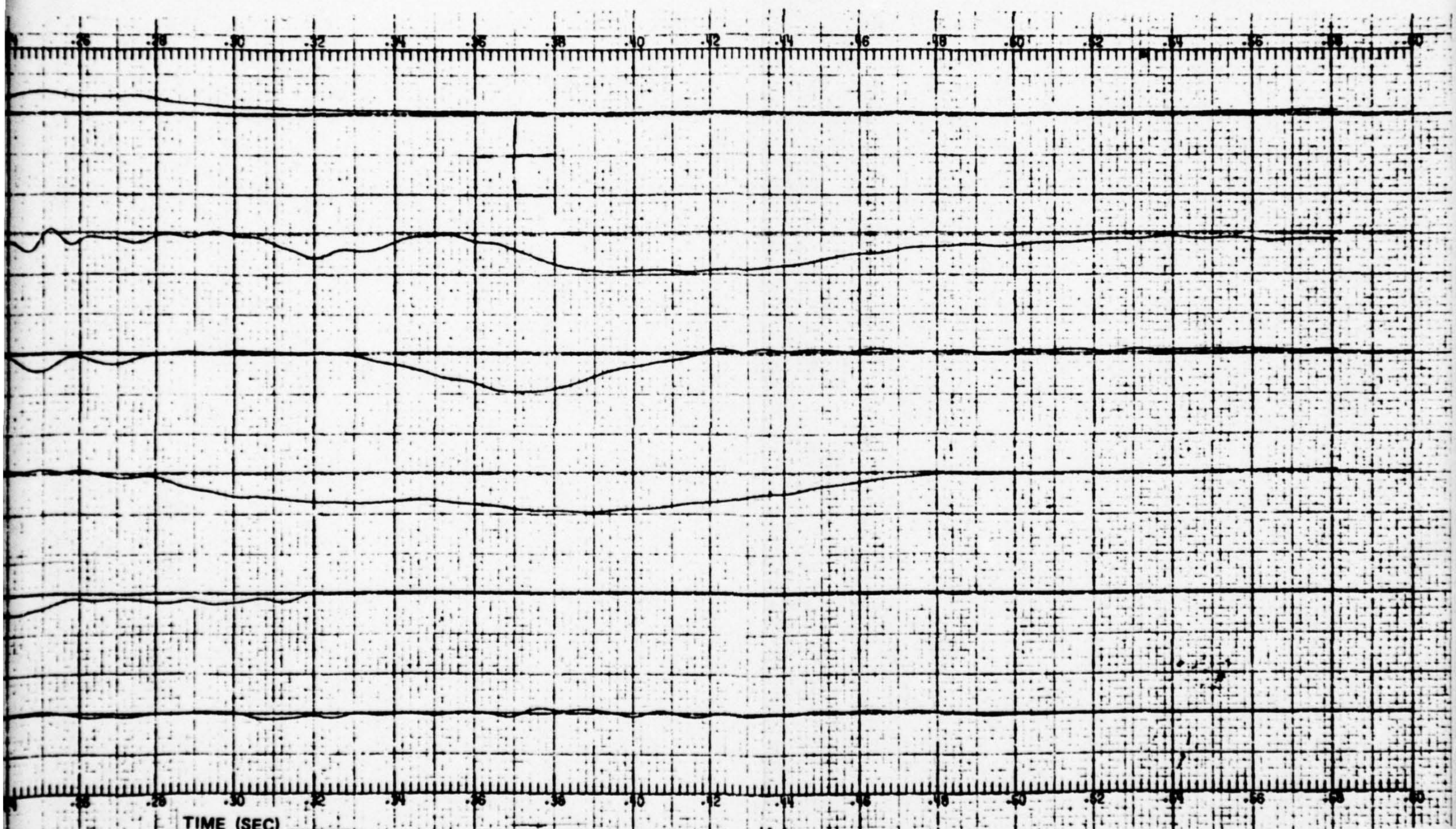
2


CH47 CRASH 2 D TAPE
100 Hz FILTERED
14 HOURS 30 MINUTES 1.818 SECONDS OR 52201.800 SECONDS
002-LB
003-LB
004-LB
005-LB
006-LB
009-LB
010-LB
011-PS
012-G
TIME (SEC)



2

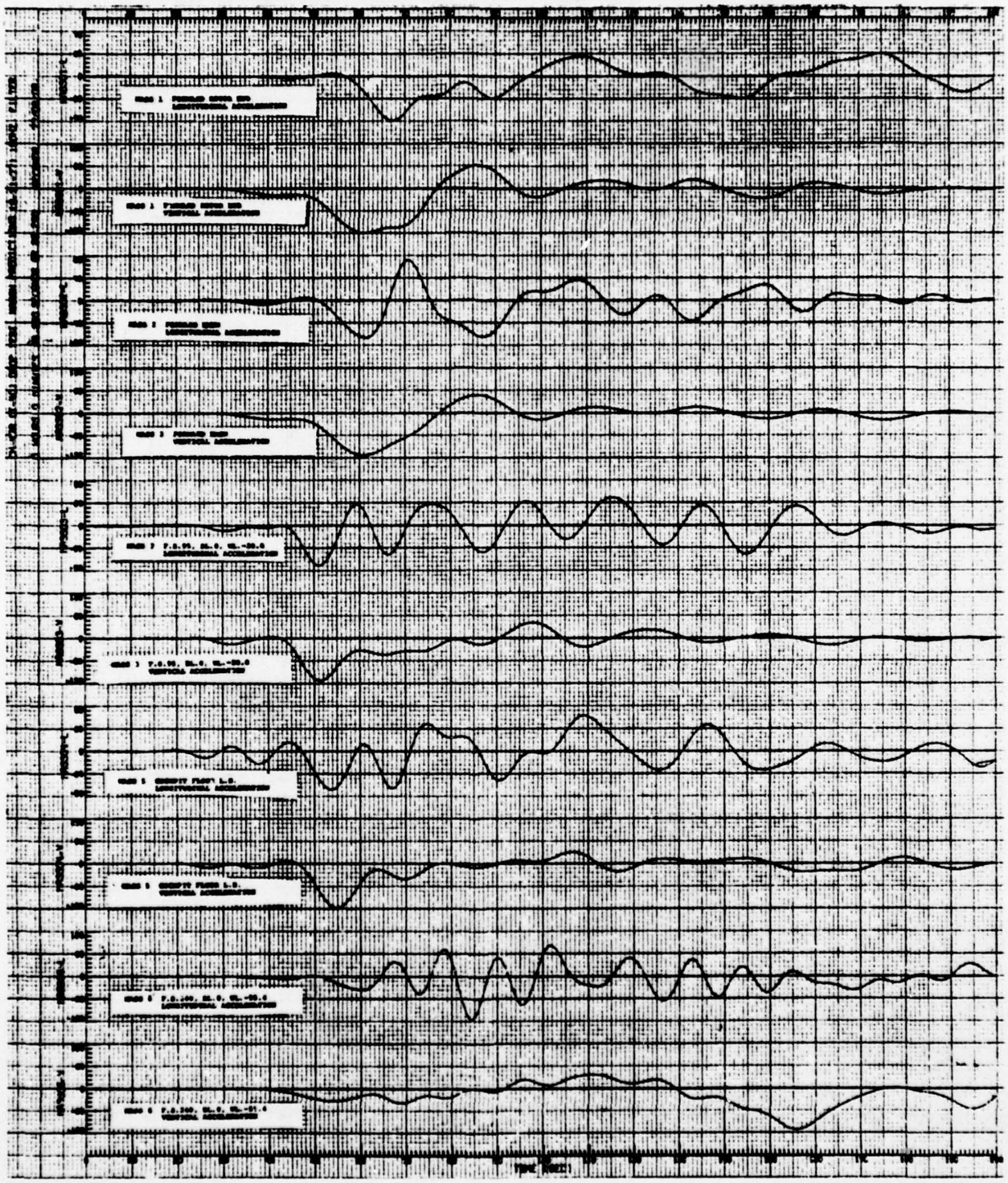

P02-LB
P03-LB
P04-LB
P05-LB
P06-LB
P09-G
TIME (SEC)

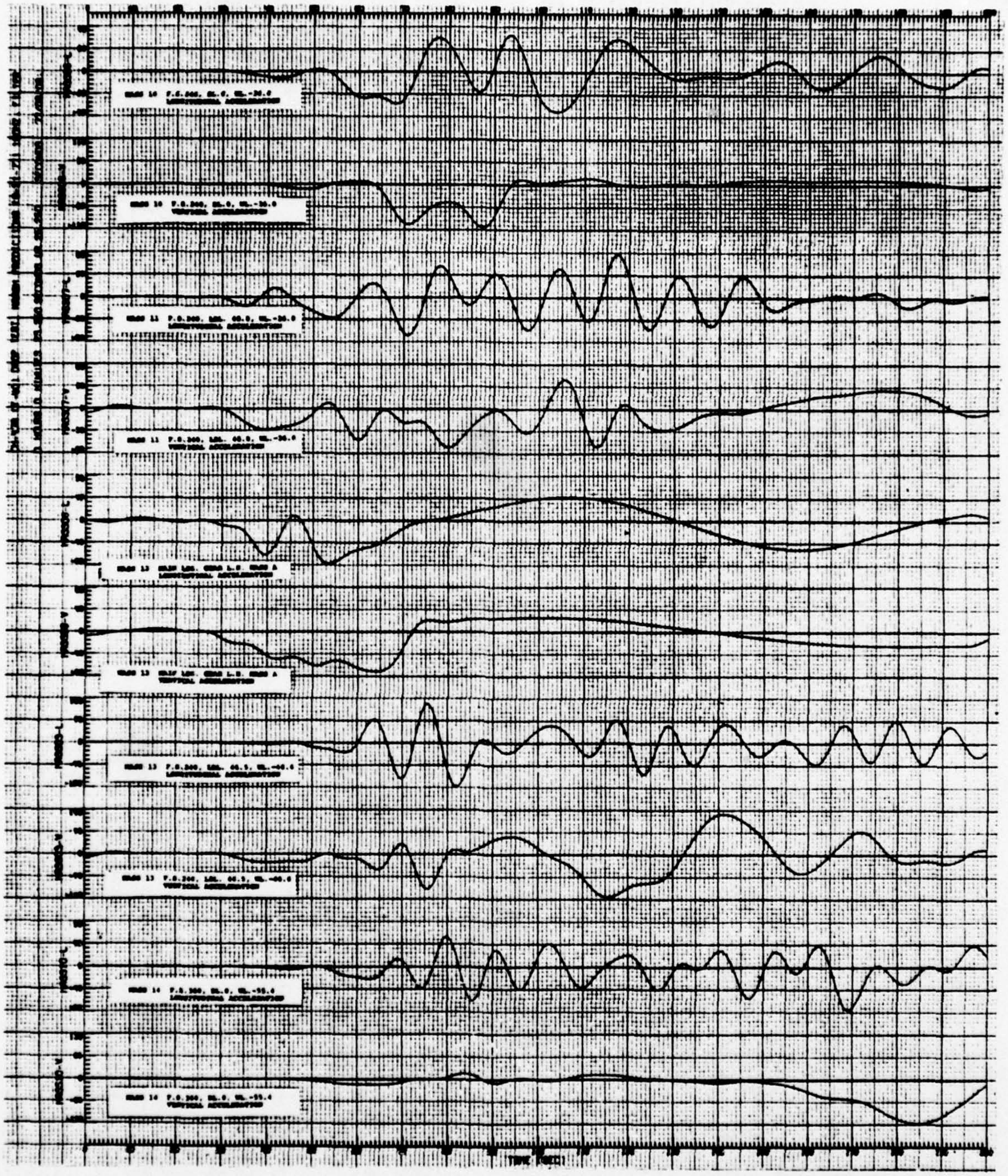


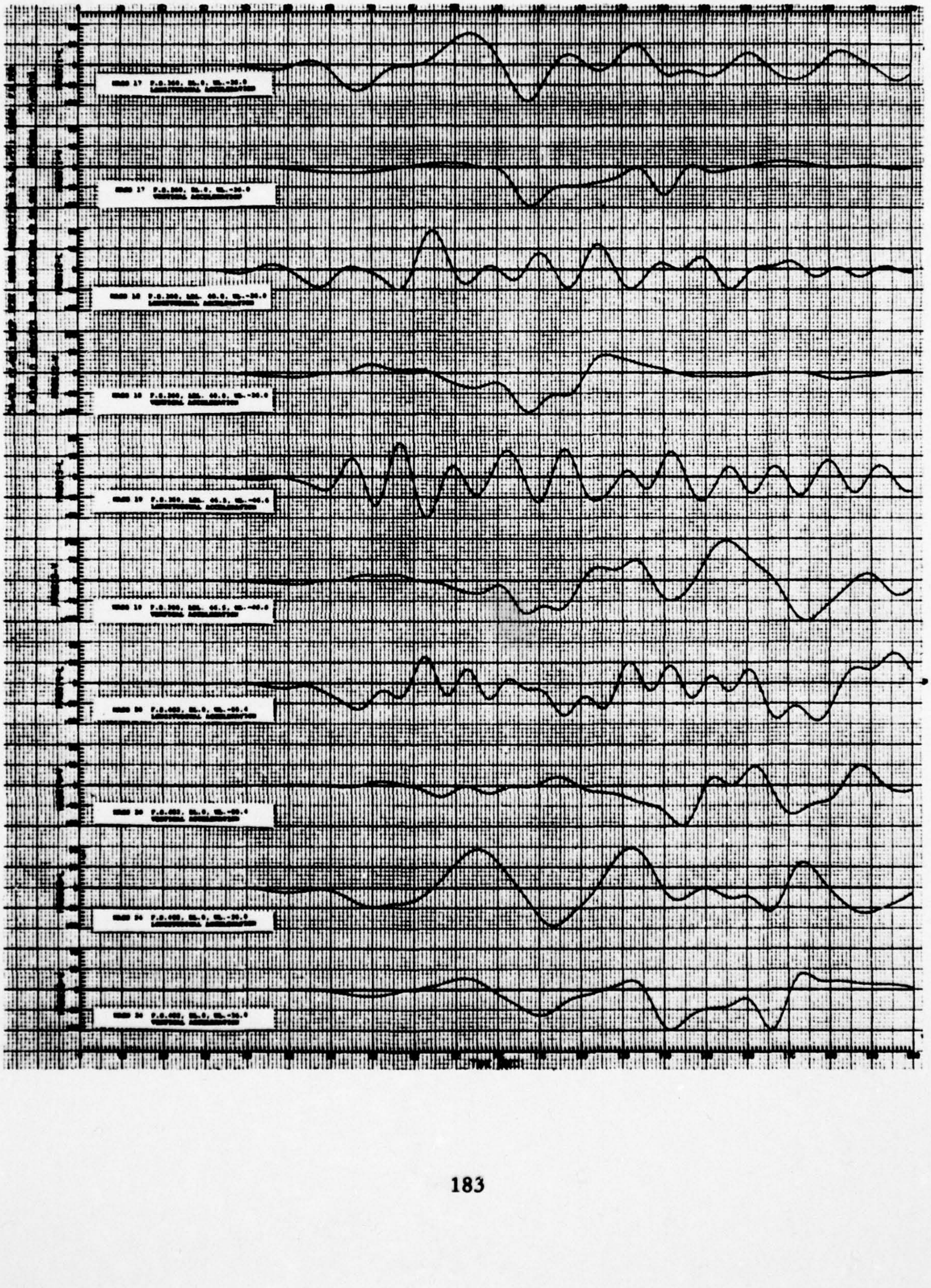
2

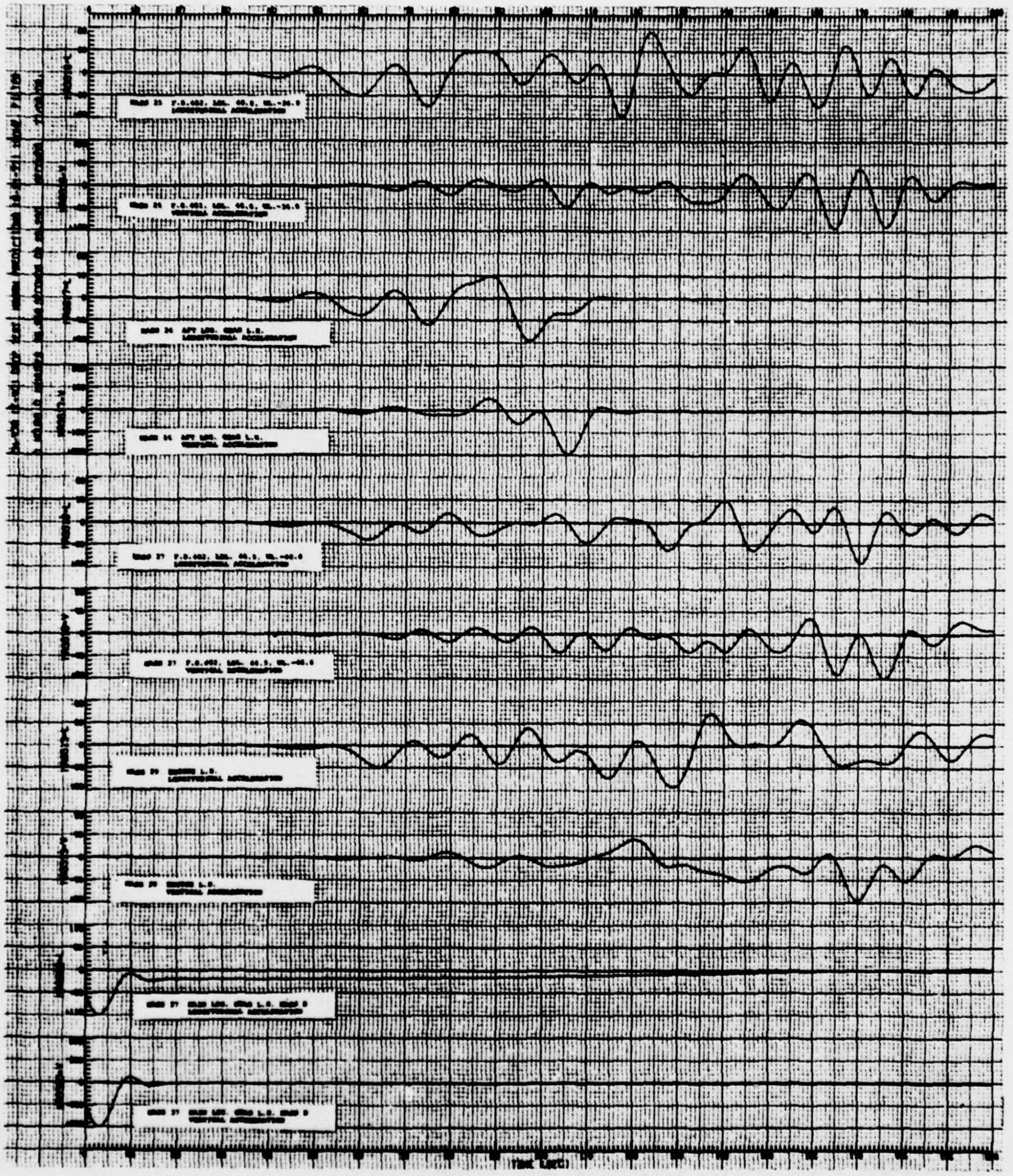
APPENDIX D

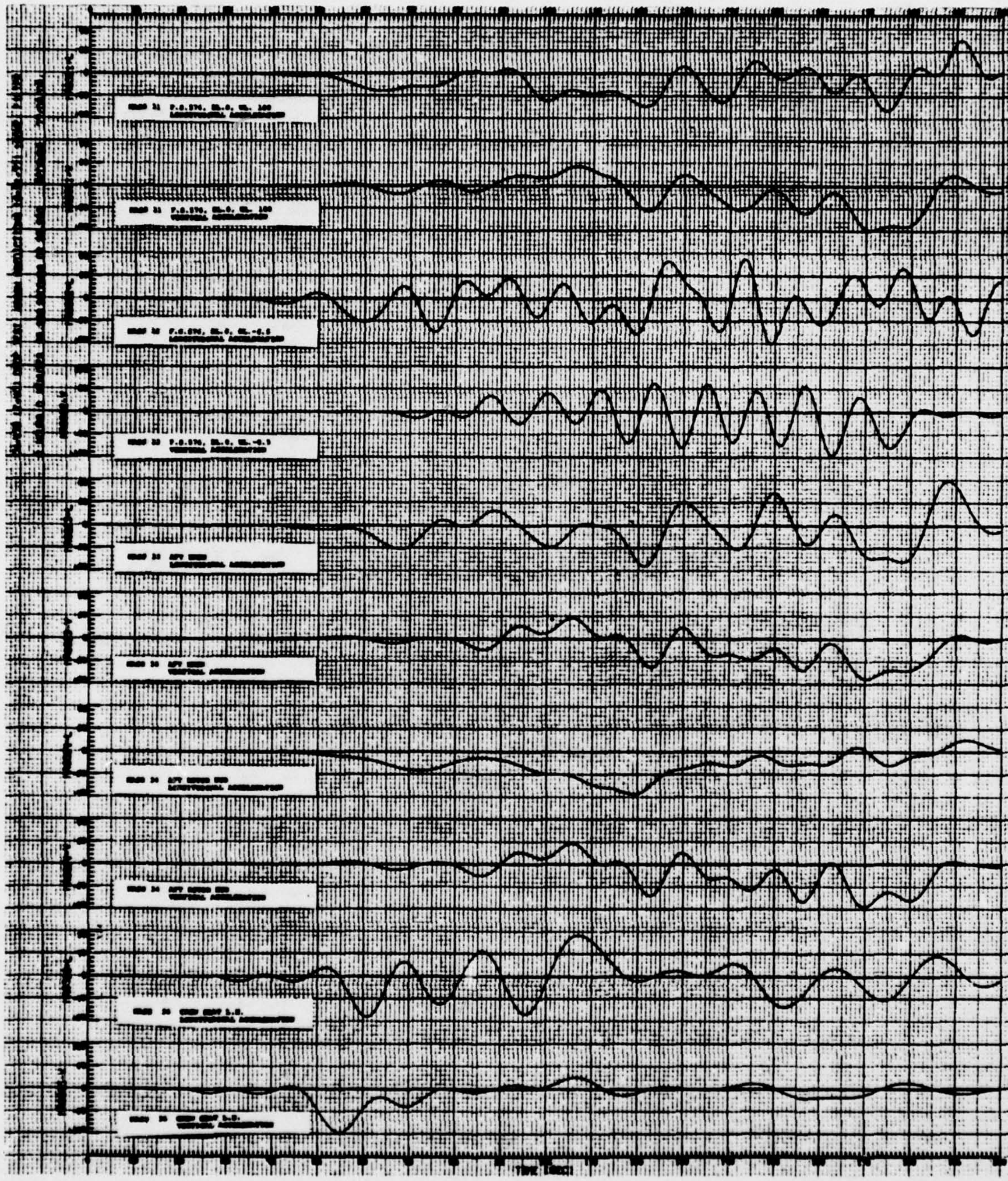
CH-47A (KRASH) IMPROVED MODEL ACCELERATIONS AT SELECTED MASS POINTS (RAW AND 100 Hz FILTERED)

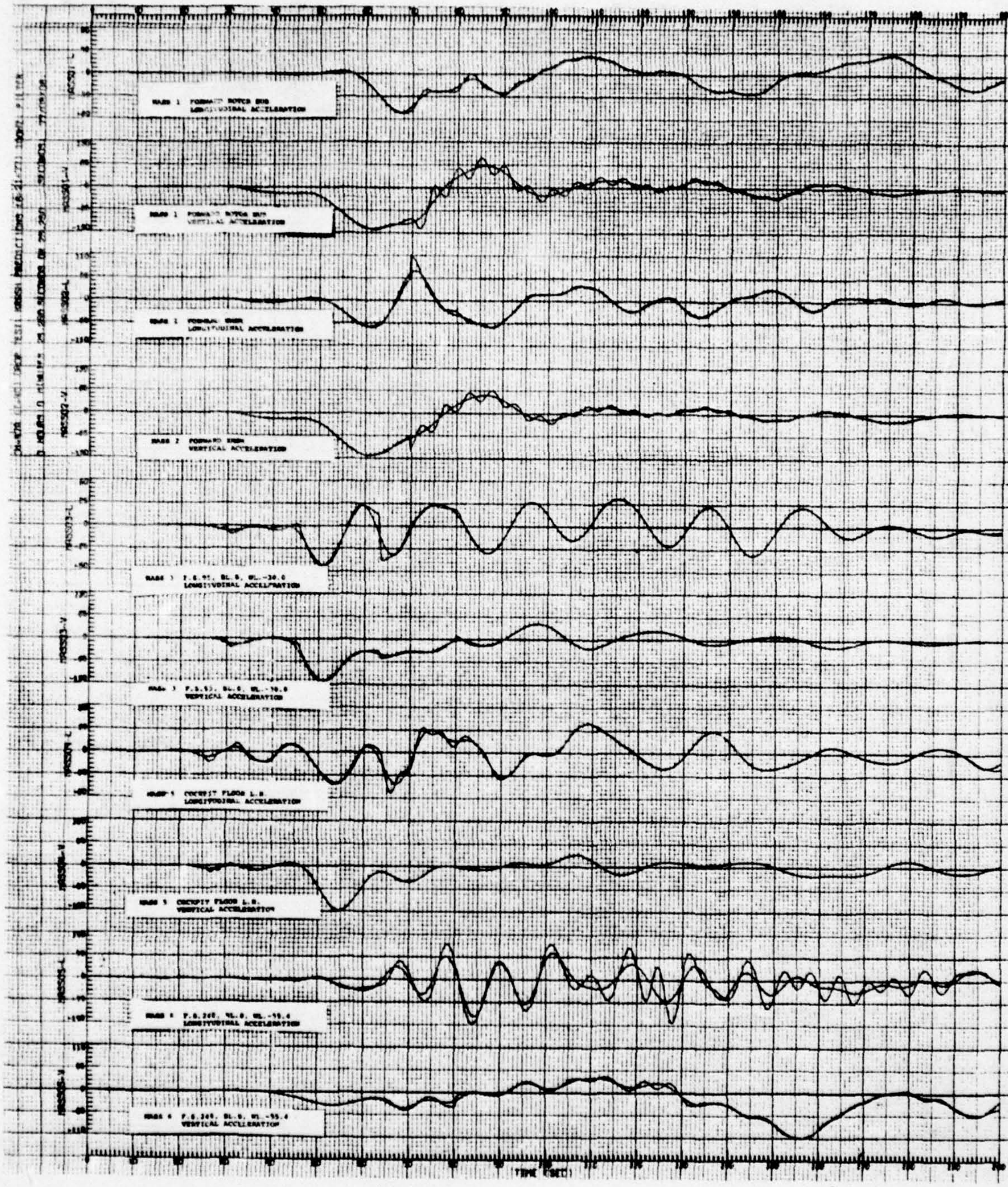


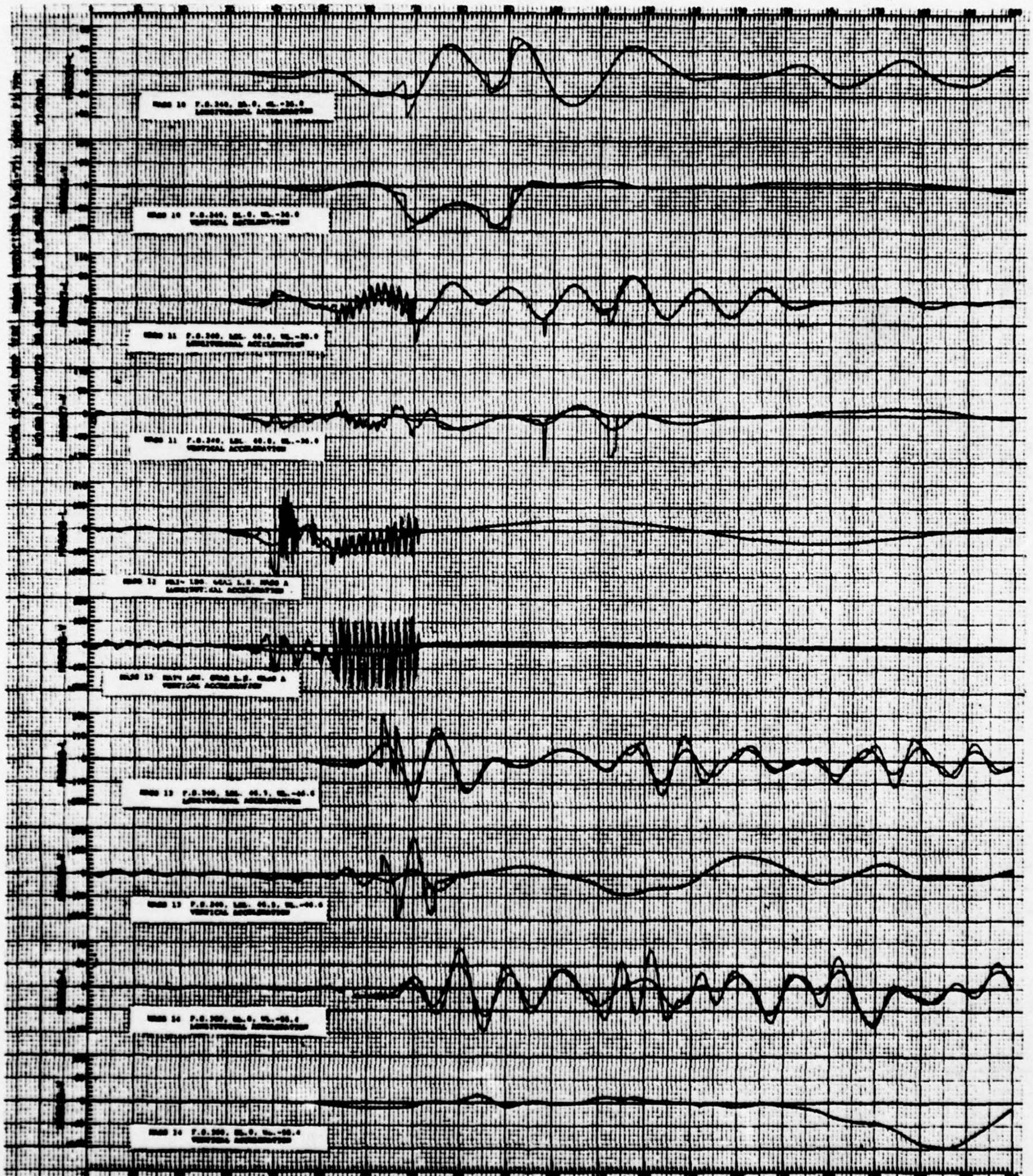


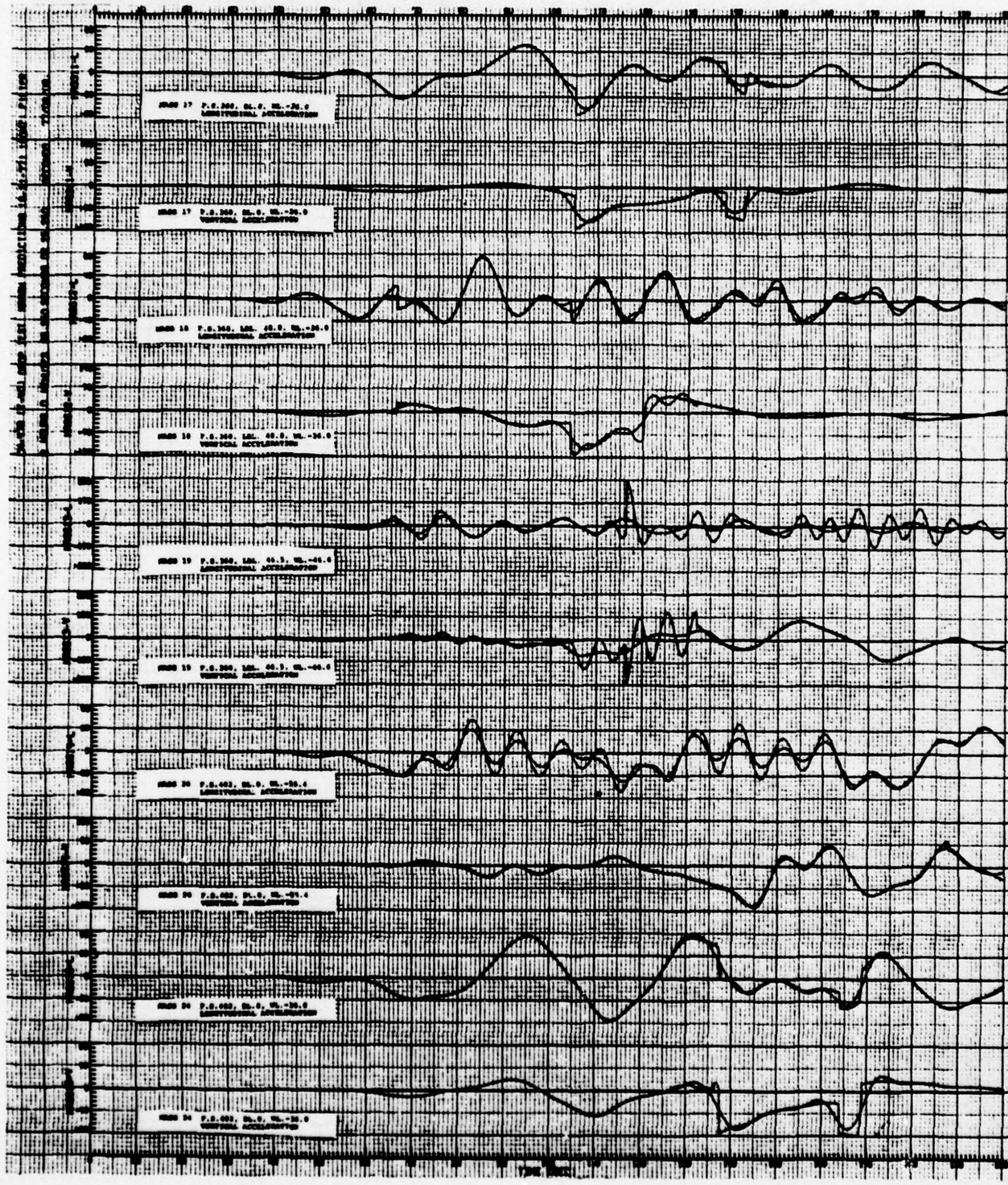


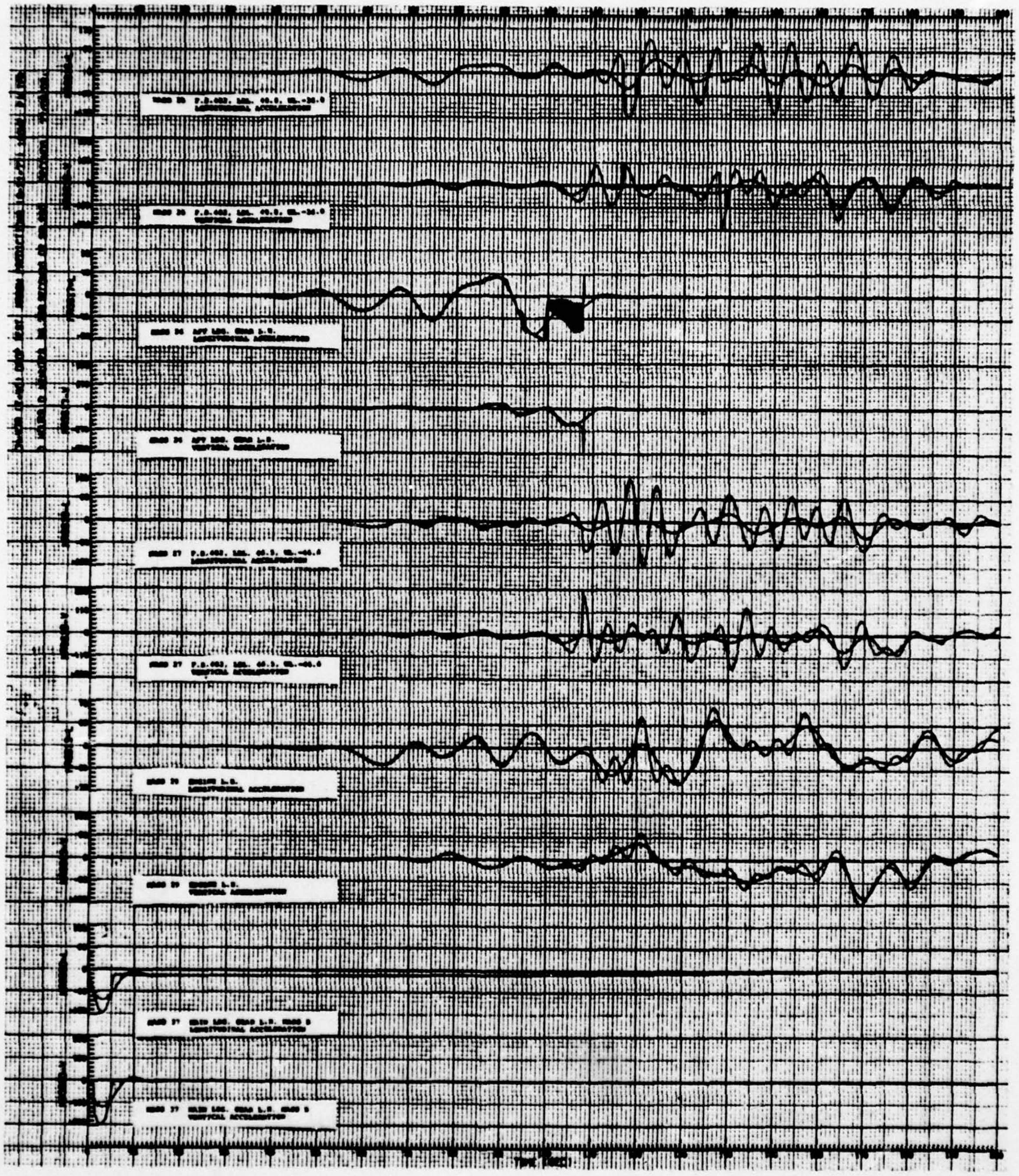


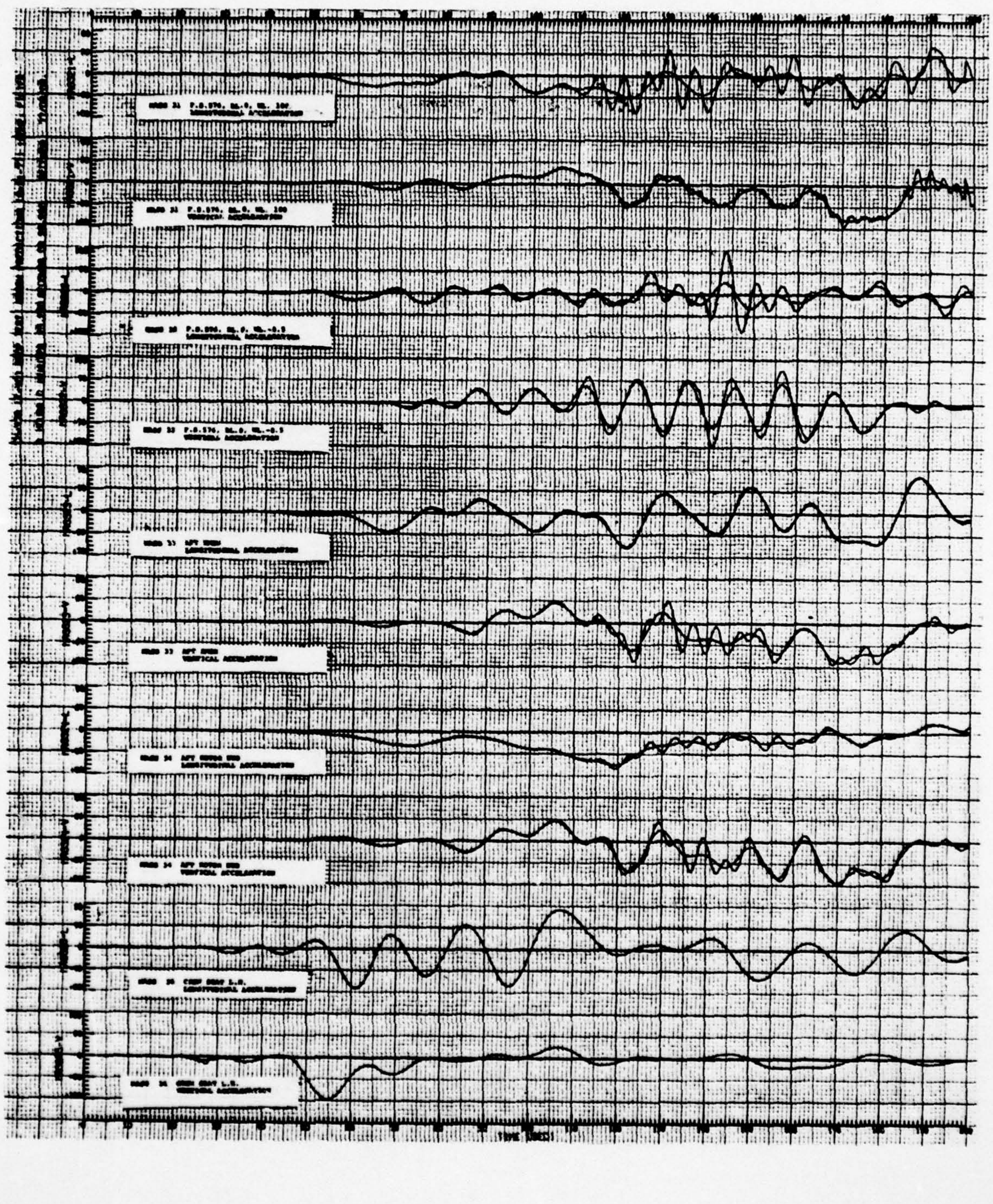










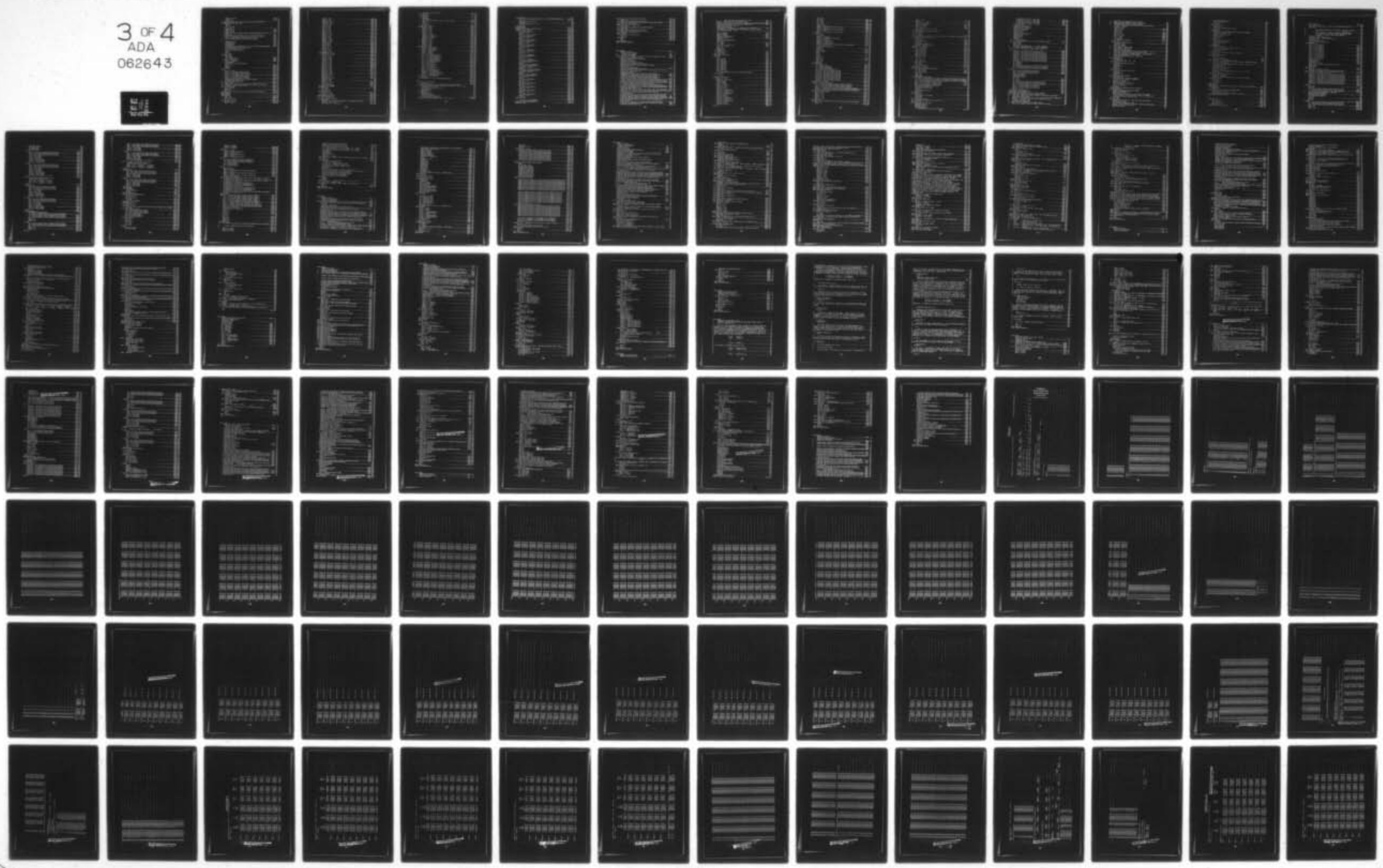


APPENDIX E
PROGRAM S7900 KRASH
LISTING


```
!CUP CI,SO
C     MEMBER NAME S79RAMN                                                0002
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*4 XKS,XKR,XKI,CHUG                                            0003
      INTEGER*4 BLANK,YIELD,PLAST
      DIMENSION LOIS(85)
      COMMON/PLOT1/ NOPLOT,NMPT(5,40),ISCALE(5),KTYPE(5),NPTC,KPLT
      COMMON/INT75/NV
      COMMON/ICSYM/NSYM(20),ISDF(40)
      COMMON/PNOS/PN(85)
      COMMON/SDFCO/SDF(85)
      COMMON/IDERV/IRUPSW(085),IPENSW(085)                               0005
      COMMON/DERIN/HEX(50),HEY(50),HEZ(50),ALIFT(50),VMAX(510)           0034
     1 ,PHIDP(50),THEDP(50),PSIDP(50),PHIPR,THEPR,PSIPR                  0035
      COMMON/DERIN1/XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR                  0036
      COMMON /IN74/ ZG,XGDOT,ZGDOT,YGDOT,PPR,QPR,RPR                     0037
      COMMON/INTG/ INBUF(50),II(121),KK(121),IR(121),JR(121),            0038
     1          IQ(121),JQ(121),LQ(121),NPQ(121),IKCT                    0039
      COMMON/ ICOPLY/ NE(085),NOS,NID(085),NCP(085),NS,L3                0039
      COMMON/VARSTP/ DELTMN,DELSV,EER,EEO,EROT,ERROR
     1,TMX,TTMX,TTTMX
      COMMON/LINES/XKS(1200),XKR(1200),NLSFLG(510),CHUG(120)
      COMMON/IPT/INPAP,IPAP
      COMMON/NINTEG/KOUNT,LOIS
      COMMON/ CMPLY/PROP(20,3),PTIM,TMEL(085),CKPT(085,4,8),EALW(085,4)0039
      COMMON/ PYLD/SIGB(085,4),TXY(085,4),TXZ(085,4),SU(085,4),SV(085,4)0039
      COMMON/IPYLD/YIELD(085,4),PLAST(085,4)
      DIMENSION DPHI(50),DTHETA(50),DPSI(50),N3(85,6),
     1 VEE2(6,85)
      COMMON/MATNCF/      IPRINT,ITPLOT,IBS(50,3)                        0016
      COMMON /BLANK1/ XX(50),XY(50),XZ(50),XL(50),XM(50),                0006
     1 XN(50),DPX(50),DPY(50),DPZ(50),DPL(50),DPM(50),DPN(50),PIN(50),   0007
     2 QIN(50),RIN(50),XI1(50),XI2(50),XI3(50),XI4(50),XI5(50),XI6(50),  0008
     3 XXK(085),XYK(085),XZK(085),XLK(085),XMK(085),XNK(085),XXJ(085),   0009
     4 XYJ(085),XZJ(085),XLJ(085),XMJ(085),XNJ(085),                     0010
     5   DELI(50),POLD(50),QOLD(50),ROLD(50),UOLD(50),VOLD(50),          0011
     6 WOLD(50),XOLD(50),YOLD(50),ZOLD(50),PINO(50),QINO(50),RINO(50),   0012
     7 OXIJ(085),OYIJ(085),OZIJ(085),PHIOLD(50),THEOLD(50),PSIOLD(50),   0013
     8 TPEN(085),TRUPT(085),DTHALF                                       0014
      COMMON /IBLANK/ IJKK,KPEN,KRUPT,IPEN(085),IRUPT(085),JRUPT(085)    0015
      COMMON/COMALL/ C(6,085),P(50),Q(50),R(50),U(50),V(50),W(50),X(50),0017
     1 Y(50),Z(50),AI(9),AJ(9),XKREF(6,85),SC(50,3),XC(6),
     A XK(3060),XI(50),
     2YI(50),ZI(50),XYI(50),XZI(50),YZI(50),AIJ(9),BIJ(450),DIJ(765),
     3 DRI(085),OAI(450),VEE(510),WGT(50),PHI(50),THETA(50),PSI(50),     0020
     4 PDOT(50),QDOT(50),RDOT(50),UDOT(50),VDOT(50),WDOT(50),XDOT(50),   0021
     5 YDOT(50),ZDOT(50),PHIDOT(50),THEDOT(50),PSIDOT(50),TIME,DELTAT,   0022
     6XACC(50),YACC(50),ZACC(50),AITAJ(9),AIDOT(9),FMBAR(6,85),
     A DELFMO(3060),
     7 PHIIJ(085),THEIJ(085),PSIIJ(085),SUMDF(6,085),TITLE(20),          0024
     8 XLBAR(50,3),FSPBAR(50,3),VEEDOT(3,3),DX(50),DY(50),DZ(50),        0025
     8 DPIN(50),DQIN(50),DRIN(50),                                       0026
     8          SEIJ(085),DEIJ(085),CEIK(50,3), TMAX                     0027
      COMMON / ICOMAL/ MAXNM,MAXIGS,MAXTBL,INDP,                         0028
     A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085),  0029
     B N(510),NN(50,3),ISP(50,3),IJPR(085),IDPLOT(010)                   0030
      EQUIVALENCE (N(1),N3(1)),(VEE(1),VEE2(1))
      DATA BLANK/4H    /                                                 0032
      MAXNM=50
      MAXIGS=85
      MAXTBL = 120                                                       0035
```

AD-A062 643 BOEING VERTOL CO PHILADELPHIA PA F/G 1/3
SIMULATION CORRELATION, AND ANALYSIS OF THE STRUCTURAL RESPONSE--ETC(U)
AUG 78 Y V BADRINATH DAAJ02-76-C-0015
UNCLASSIFIED D210-11354-1 USARTL-TR-78-24 NL

3 OF 4
ADA
062643



```
      SINER=1./10.E10                                                  0035
      IPLSW = 0                                                        0036
      PTIM=-1.E10
C PARAMETERS KOUNT JOE & FACTOR ARE USED TO EASE INTEGRATION
C  PROBLEMS FOR RUPTURE CASES
      KOUNT=0
      KPLT=0
      DO 9 IJ=1,85
    9 LOIS(IJ)=0
      READ 7,TITLE                                                     0036
    7 FORMAT(20A4)                                                     0036
      PRINT 8,TITLE                                                    0036
    8 FORMAT(1H1,20A4,10X,'LOAD MODULE S79TEST CREATED 6-17-76'////)
      PRINT 12                                                         0036
   12 FORMAT(2X,'****  CONTROL DATA   ****',/2X,'CODE NO.',5X,         0036
     1'RSTIME',7X,'XPRS',7X,'XNCASE',7X,'XPLOT',6X,'ATMCK')            0036
    1 READ 6, XCODE,RSTIME,XPRS,XNCASE,XPLOT,ATMCK                     0037
      PRINT 6,XCODE,RSTIME,XPRS,XNCASE,XPLOT,ATMCK                     0037
C                                                                      0037
    6 FORMAT(6E12.4)                                                   0037
      NCODE=XCODE+.01                                                  0037
      NCASE=XNCASE                                                     0037
      NOPLOT=XPLOT                                                     0037
      IF(RSTIME.GT.0.0.AND.NCODE.GT.0) CALL RSTRT(RSTIME,XPRS,NCODE)   0037
      IF(RSTIME.GT.0.0) DT2=DELSV+DELTAT
      IF(RSTIME.EQ.0.0) GO TO 100
      CALL RSTRT(RSTIME,XPRS,10)
      IPC=0
      IPAR=0
      GO TO 310
  100 CONTINUE
      CALL INPUT
      CALL PLASTN                                                      0037
      IF(NM) 1000,1000,2                                               0038
    2 DT2 = 2.0*DELTAT                                                 0039
      DTHALF = .5*DELTAT                                               0040
      DELTMN=DELTAT
      IF(RSTIME.GT.0.) DT2=2.*DELTAT
      KRUPT = 0                                                        0041
      JPLOT = 0                                                        0042
      KPEN=0                                                           0043
      NTEMP=0                                                          0043
C (26)                                                                 0044
      DO 135 I=1,NM                                                    0045
      XI1(I) = YI(I)*ZI(I)-YZI(I)*YZI(I)                               0046
      XI2(I) = XYI(I)*ZI(I)+XZI(I)*YZI(I)                              0047
      XI3(I) = XYI(I)*YZI(I)+YI(I)*XZI(I)                              0048
      XI4(I) = XI(I)*YZI(I)+XZI(I)*XYI(I)                              0049
      XI5(I) = XI(I)*ZI(I)-XZI(I)*XZI(I)                               0050
      XI6(I) = XI(I)*YI(I)-XYI(I)*XYI(I)                               0051
      TEMP=XI(I)*XI1(I)-XYI(I)*XI2(I)-XZI(I)*XI3(I)                    0051
      IF(TEMP-SINER)110,110,130                                        0051
  110 IF(NTEMP.EQ.0) PRINT 112                                         0051
      PRINT 115,I                                                      0051
  112 FORMAT(1H1/////15X'THE FOLLOWING MASS ELEMENTS HAVE ZERO ',      0051
     1 'INERTIA VALUES'//25X'MASS NO'/)                                0051
  115 FORMAT(38X,I4)                                                   0051
      DELI(I)=10.E10                                                   0051
      NTEMP=1                                                          0051
      GO TO 135                                                        0051
  130 DELI(I) = 1.0/(XI(I)*XI1(I)-XYI(I)*XI2(I)-XZI(I)*XI3(I))         0052
  135 CONTINUE                                                         0052
  136 CONTINUE
C ZERO ARRAYS                                                          0053
      TIME = 0.0                                                       0054
      NM9 = 9*NM                                                       0055
      DO 140 I = 1,NM9                                                 0056
  140 BIJ(I) = 0.0                                                     0057
      DO 150 I = 1,NM                                                  0058
      DX(I) = 0.0                                                      0059
```

```
      DY(I) = 0.0
      DZ(I) = 0.0
      DPHI(I) = 0.0
      DTHETA(I) = 0.0
      DPSI(I) = 0.0
      XX(I) = 0.0
      XY(I) = 0.0
      XZ(I) = 0.0
      XL(I) = 0.0
      XM(I) = 0.0
      XN(I) = 0.0
      DPX(I) = 0.0
      DPY(I) = 0.0
      DPZ(I) = 0.0
      DPL(I) = 0.0
      DPM(I) = 0.0
      DPN(I) = 0.0
      DPIN(I) = 0.0
      DQIN(I) = 0.0
      DRIN(I) = 0.0
      XACC(I)=0.0
      YACC(I)=0.0
      ZACC(I)=0.0
      DO 150 K = 1,3
      IBS(I,K) = 0
      NN(I,K) = 0
      SC(I,K) = 0.0
      CEIK(I,K)=0.0
  150 FSPBAR(I,K) = 0.0
      DO 160 IJ = 1,IGS
      XXK(IJ) = 0.0
      XXJ(IJ) = 0.0
      XYK(IJ) = 0.0
      XYJ(IJ) = 0.0
      XZK(IJ) = 0.0
      XZJ(IJ) = 0.0
      XLK(IJ) = 0.0
      XLJ(IJ) = 0.0
      XMK(IJ) = 0.0
      XMJ(IJ) = 0.0
      XNK(IJ) = 0.0
      XNJ(IJ) = 0.0
      OXIJ(IJ) = 0.0
      OYIJ(IJ) = 0.0
      OZIJ(IJ) = 0.0
      SEIJ(IJ) = 0.0
      DEIJ(IJ) = 0.0
      DO 160 L=1,6
      SUMDF(L,IJ) = 0.0
      XKREF(L,IJ)=0.
      FMBAR(L,IJ)=0.
      N3(IJ,L) = 0
      VEE2(L,IJ) = 0.0
      DO 151 K=1,4
      YIELD(IJ,K)=BLANK
  151 PLAST(IJ,K)=BLANK
  160 CONTINUE
      K= 6+6*IGS
      DO 161 L=1,K
  161 DELFMO(L)=0.
      DO 165 J = 1,3
      DO 165 K = 1,3
  165 VEEDOT(J,K) = 0.0
C DO INITIAL CONDITIONS
      CALL IC(ATMCK)
C DO ALL THE (AIJ) INTO DIJ
      CALL DOAIJ
C     ROUTINE TMCK CALCULATES FREQUENCY IF REQUESTED 8-12-75 EW
      IF(ATMCK.GT.0.) CALL TMCK
      IF(ATMCK.GT.0.)  GO TO 164
```

```
      IF(ATMCK.EQ.0.) GO TO 167                                    0117
  166 ATMCK=0.                                                     0117
      GO TO 136
  167 CONTINUE                                                     0117
      ERROR=0.
      CALL DERIV                                                   0118
      IF(TIME.GT.PTIM.AND.PTIM.GE.0.) CALL PLAYLD                  0119
      IPC = 0                                                      0120
      IPAP=0
      CALL PRINT                                                   0121
      DO 200 I = 1,NM                                              0122
C PRESET OLD VALUES                                                0123
      PINO(I) = 0.0                                                0124
      QINO(I) = 0.0                                                0125
      RINO(I) = 0.0                                                0126
      XOLD(I) = X(I)                                               0127
      YOLD(I) = Y(I)                                               0128
      ZOLD(I) = Z(I)                                               0129
      PHIOLD(I) = PHI(I)                                           0130
      THEOLD(I) = THETA(I)                                         0131
      PSIOLD(I) = PSI(I)                                           0132
      POLD(I) = P(I)                                               0133
      QOLD(I) = Q(I)                                               0134
      ROLD(I) = R(I)                                               0135
      UOLD(I) = U(I)                                               0136
      VOLD(I) = V(I)                                               0137
      WOLD(I) = W(I)                                               0138
C DO 1ST STEP EULER                                                0139
      DPIN(I) = DELTAT*P(I)                                        0140
      DQIN(I) = DELTAT*Q(I)                                        0141
      DRIN(I) = DELTAT*R(I)                                        0142
      PIN(I) = DPIN(I)                                             0143
      QIN(I) = DQIN(I)                                             0144
      RIN(I) = DRIN(I)                                             0145
      P(I) = P(I)+DELTAT*PDOT(I)                                   0146
      Q(I) = Q(I)+DELTAT*QDOT(I)                                   0147
      R(I) = R(I)+DELTAT*RDOT(I)                                   0148
      U(I) = U(I)+DELTAT*UDOT(I)                                   0149
      V(I) = V(I)+DELTAT*VDOT(I)                                   0150
      W(I) = W(I)+DELTAT*WDOT(I)                                   0151
      DX(I) = DELTAT*XDOT(I)                                       0152
      X(I) = X(I)+DX(I)                                            0153
      DY(I) = DELTAT*YDOT(I)                                       0154
      Y(I) = Y(I)+DY(I)                                            0155
      DZ(I) = DELTAT*ZDOT(I)                                       0156
      Z(I) = Z(I)+DZ(I)                                            0157
      DPHI(I) = DELTAT*PHIDOT(I)                                   0158
      PHI(I) = PHI(I)+DPHI(I)                                      0159
      DTHETA(I) = DELTAT*THEDOT(I)                                 0160
      THETA(I) = THETA(I)+DTHETA(I)                                0161
      DPSI(I) = DELTAT*PSIDOT(I)                                   0162
      PSI(I) = PSI(I)+DPSI(I)                                      0163
  200 CONTINUE                                                     0164
      IF(NCODE.GT.0) CALL RSTRT(RSTIME,XPRS,10)                    0164
C                                                                  0164
C                                                                  0164
  190 TIME = TIME+DELTAT                                           0165
      CALL DERIV                                                   0166
C   THIS CODE DECREASES TIME INCREMENT DELTAT FOR RUPTURES
C  IT WAS INTRODUCED TO HANDLE INTEGRATION PROBLEMS    E.W. 2-11-76
      IF(KOUNT.EQ.0) GO TO 191
      IF(DELTMN.GE.DELTAT) GO TO 191
      DELTAT=DELTMN
      ERROR=ERROR+1
  191 IPC=IPC+1
      DT2=DELSV+DELTAT
      DTHALF=.5*DELTAT
      IF(TIME.GE.TMAX) GO TO 270
      IF(IPC-IPRINT) 310,270,270                                   0168
  270 IF(TIME.GT.PTIM.AND.PTIM.GE.0.) CALL PLAYLD                  0168
```

```
  185 CONTINUE
      IF(TIME.GE.RSTIME.AND.NCODE.GT.0) CALL RSTRT(RSTIME,XPHS,10)
      IPC = 0
      IF(INPAP.EQ.0) GO TO 192
      IPAP=IPAP+1
      IF(IPAP.LT.INPAP) GO TO 310
      IPAP=0
  192 CALL PRINT
  310 CONTINUE
C PREDICT, MOVE DOWN, AND DO DELTA'S
  280 DO 300 I = 1,NM
      T = PINO(I)+DT2*P(I)
      PINO(I) = PIN(I)
      PIN(I) = T
      DPIN(I) = PIN(I)-PINO(I)
      T = QINO(I)+DT2*Q(I)
      QINO(I) = QIN(I)
      QIN(I) = T
      DQIN(I) = QIN(I)-QINO(I)
      T = RINO(I)+DT2*R(I)
      RINO(I) = RIN(I)
      RIN(I) = T
      DRIN(I) = RIN(I)-RINO(I)
      T = XOLD(I)+DT2*XDOT(I)
      XOLD(I) = X(I)
      X(I) = T
      DX(I) = X(I)-XOLD(I)
      T = YOLD(I)+DT2*YDOT(I)
      YOLD(I) = Y(I)
      Y(I) = T
      DY(I) = Y(I)-YOLD(I)
      T = ZOLD(I)+DT2*ZDOT(I)
      ZOLD(I) = Z(I)
      Z(I) = T
      DZ(I) = Z(I)-ZOLD(I)
      T = PHIOLD(I)+DT2*PHIDOT(I)
      PHIOLD(I) = PHI(I)
      PHI(I) = T
      DPHI(I) = PHI(I)-PHIOLD(I)
      T = THEOLD(I)+DT2*THEDOT(I)
      THEOLD(I) = THETA(I)
      THETA(I) = T
      DTHETA(I) = THETA(I)-THEOLD(I)
      T = PSIOLD(I)+DT2*PSIDOT(I)
      PSIOLD(I) = PSI(I)
      PSI(I) = T
      DPSI(I) = PSI(I)-PSIOLD(I)
      T = POLD(I)+DT2*PDOT(I)
      POLD(I) = P(I)
      P(I) = T
      T = QOLD(I)+DT2*QDOT(I)
      QOLD(I) = Q(I)
      Q(I) = T
      T = ROLD(I)+DT2*RDOT(I)
      ROLD(I) = R(I)
      R(I) = T
      T = UOLD(I)+DT2*UDOT(I)
      UOLD(I) = U(I)
      U(I) = T
      T = VOLD(I)+DT2*VDOT(I)
      VOLD(I) = V(I)
      V(I) = T
      T = WOLD(I)+DT2*WDOT(I)
      WOLD(I) = W(I)
      W(I) = T
  300 CONTINUE
C
      IF(TIME-TMAX) 190,190,500
  500 IF (KRUPT) 5500,5500,5000
 5000 PRINT 2000
```

```
2000 FORMAT(1H1,7X,15HRUPTURE SUMMARY,/)
     PRINT 3000
3000 FORMAT(1H ,9X,1HI,9X,1HJ,7X,4HTIME,/)
     PRINT 4000,(IRUPT(KRT),JRUPT(KRT),TRUPT(KRT),KRT=1,KRUPT)
4000 FORMAT(1H ,2I10,F10.5)
5500 IF (KPEN.LE.0)  GO TO 6000
     PRINT 5501
5501 FORMAT(1H1,7X,'CONTROL VOLUME PENETRATIONS' //)
     PRINT 5502
5502 FORMAT(1H ,13X,'TIME',10X,'MASS' /)
     PRINT 5503,(TPEN(K),IPEN(K),K=1,KPEN)
5503 FORMAT(1H ,10X,F10.5,I10)
6000 CONTINUE
     IF(NCASE.LE.0) GO TO 1000
     GO TO 1
1000 CONTINUE
     STOP
     END
!ASS (M:SO,LO)
!ASS (M:CI,D5,S79REU:F)


!CUP CI,SO
      SUBROUTINE DERIV
      IMPLICIT REAL*8(A-H,O-Z)
C       MEMBER NAME S79RDERV
C      MEMBER NAME S79RDERV
C NOTE FOR DOUBLE PRECISION T TEST IN LINE 00620000 SHOULD BE 'E10'
      REAL*4 XKS,XKI,XKR,AXK,CHUG,PTR
      INTEGER*4 BLANK,ASTRIC,YIELD,PLAST
      DIMENSION LOIS(85)
      DIMENSION RP(3),DXD(3)
      COMMON/DLAR/PTHO(85),YAWO(85)
      COMMON/IPYLD/YIELD(85,4),PLAST(85,4)
      COMMON/VARSTP/ DELTMN,DELSV,EER,EEO,EROT,ERROR
     1,TMX,TTMX,TTTMX
      COMMON/NINTEG/KOUNT,LOIS
      COMMON/IDERV/IRUPSW(085),IPENSW(085)
      DIMENSION SINCOS(6),CIJ(450),DAI(9),DD(6),DF(6),D(6),AIAIJT(9),
     1 AP(9),SIGF(6,85),VEE2(6,85)
      COMMON/PNOS/PN(85)
      COMMON/DERIN1/XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR
      COMMON/DERIN/HEX(50),HEY(50),HEZ(50),ALIFT(50),VMAX(510)
     1 ,PHIDP(50),THEDP(50),PSIDP(50),PHIPR,THEPR,PSIPR
      COMMON/LINES/XKS(1200),XKR(1200),NLSFLG(510),CHUG(120)
      COMMON /BLANK1/ XX(50),XY(50),XZ(50),XL(50),XM(50),
     1 XN(50),DPX(50),DPY(50),DPZ(50),DPL(50),DPM(50),DPN(50),PIN(50),
     2 QIN(50),RIN(50),XI1(50),XI2(50),XI3(50),XI4(50),XI5(50),XI6(50),
     3 XXK(085),XYK(085),XZK(085),XLK(085),XMK(085),XNK(085),XXJ(085),
     4 XYJ(085),XZJ(085),XLJ(085),XMJ(085),XNJ(085),
     5   DELI(50),POLD(50),QOLD(50),ROLD(50),UOLD(50),VOLD(50),
     6 WOLD(50),XOLD(50),YOLD(50),ZOLD(50),PINO(50),QINO(50),RINO(50),
     7 OXIJ(085),OYIJ(085),OZIJ(085),PHIOLD(50),THEOLD(50),PSIOLD(50),
     8 TPEN(085),TRUPT(085),DTHALF
      COMMON /IBLANK/ IJKK,KPEN,KRUPT,IPEN(085),IRUPT(085),JRUPT(085)
      COMMON/COMALL/ C(6,085),P(50),Q(50),R(50),U(50),V(50),W(50),X(50),
     1 Y(50),Z(50),AI(9),AJ(9),XKREF(6,85),SC(50,3),XC(6),
     A XK(3060),XI(50),
     2YI(50),ZI(50),XYI(50),XZI(50),YZI(50),AIJ(9),BIJ(450),DIJ(765),
     3 DRI(085),OAI(450),VEE(510),WGT(50),PHI(50),THETA(50),PSI(50),
     4 PDOT(50),QDOT(50),RDOT(50),UDOT(50),VDOT(50),WDOT(50),XDOT(50),
     5 YDOT(50),ZDOT(50),PHIDOT(50),THEDOT(50),PSIDOT(50),TIME,DELTAT,
     6XACC(50),YACC(50),ZACC(50),AITAJ(9),AIDOT(9),FMBAR(6,85),
     A DELFMO(3060),
     7 PHIIJ(085),THEIJ(085),PSIIJ(085),SUMDF(6,085),TITLE(20),
     8 XLBAR(50,3),FSPBAR(50,3),VEEDOT(3,3),DX(50),DY(50),DZ(50),
     8 DPIN(50),DQIN(50),DRIN(50),
```

```
8            SEIJ(085),DEIJ(085),CEIK(50,3), TMAX                      0027
 COMMON / TCOMAL/ MAXNM,MAXIGS,MAXTBL,INDP,                           0031
A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085),    0029
B N(510),NN(50,3),ISP(50,3),IJPR(085),IDPLOT(010)                     0030
 COMMON/ICSYM/NSYM(20),ISDF(40)
 COMMON/SDFCO/SDF(85)
 EQUIVALENCE (S1,SINCOS(1)),(C1,SINCOS(2)),(S2,SINCOS(3)),            0034
1 (C2,SINCOS(4)),(S3,SINCOS(5)),(C3,SINCOS(6)),(VEE(1),VEE2(1))
 DATA ASTRIC,BLANK/4H   *,4H    /
C
 SIN(G)= DSIN(G)                                                      0055
 COS(G)= DCOS(G)                                                      0056
 ABS(G)= DABS(G)                                                      0057
 ATAN2(F,G)= DATAN2(F,G)                                              0058
 SQRT(G)= DSQRT(G)                                                    0059
 ZERO=0.0
 PI=3.14159265358979324D0
 PI2=.5D0*PI
 TT = .2D0                                                            0040
 ET = .8D0                                                            0041
 IF(TIME.NE.0.0) GO TO 60                                             0042
 DO 70 IJ = 1,IGS                                                     0043
 SDF(IJ)=0.
 PTHO(IJ)=0.
 YAWO(IJ)=0.
70 IRUPSW(IJ) = 0                                                     0044
 DO 72 I=1,NM                                                         0045
72 IPENSW(I)=0                                                        0046
C DO ALL THE (AI)((AJ))                                                0047
60 JK=1                                                               0047
 JL=1                                                                 0047
 DO 10 I=1,NM                                                         0048
 ARG = PHI(I)                                                         0049
 S1 = SIN(ARG)                                                        0050
 C1 = COS(ARG)                                                        0051
 ARG = THETA(I)                                                       0052
 S2 = SIN(ARG)                                                        0053
 C2 = COS(ARG)                                                        0054
 ARG = PSI(I)                                                         0055
 S3 = SIN(ARG)                                                        0056
 C3 = COS(ARG)                                                        0057
 DO 40 J = 1,6                                                        0058
    IF(ABS(SINCOS(J)).LT.1.E-10) SINCOS(J)= ZERO                      0087
40 CONTINUE                                                           0064
C                                                                     0065
 J = 9*(I-1)                                                          0066
C MOVE AI S TO OLD AI S                                               0067
 DO 4 JJ = 1,9                                                        0068
4 OAI(J+JJ) = BIJ(J+JJ)                                               0069
 S1S2 = S1*S2                                                         0070
 C1S2 = C1*S2                                                         0071
 AI(1) = C2*C3                                                        0072
 BIJ(J+1) = AI(1)                                                     0073
 AI(2) = C2*S3                                                        0074
 BIJ(J+2) = AI(2)                                                     0075
 AI(3) = -S2                                                          0076
 BIJ(J+3) = AI(3)                                                     0077
 AI(4) = -C1*S3+S1S2*C3                                               0078
 BIJ(J+4) = AI(4)                                                     0079
 AI(5) = C1*C3+S1S2*S3                                                0080
 BIJ(J+5) = AI(5)                                                     0081
 AI(6) = S1*C2                                                        0082
 BIJ(J+6) = AI(6)                                                     0083
 AI(7) = S1*S3+C1S2*C3                                                0084
 BIJ(J+7) = AI(7)                                                     0085
 AI(8) = -S1*C3+C1S2*S3                                               0086
 BIJ(J+8) = AI(8)                                                     0087
 AI(9) = C1*C2                                                        0088
 BIJ(J+9) = AI(9)                                                     0089
C (27)                                                                0090
```

```
      PP = P(I)
      QQ = Q(I)
      RR = R(I)
      UU = U(I)
      VV = V(I)
      WW = W(I)
      XDOTI = XDOT(I)
      XDOT(I) = AI(1)*UU+AI(4)*VV+AI(7)*WW
      YDOTI = YDOT(I)
      YDOT(I) = AI(2)*UU+AI(5)*VV+AI(8)*WW
      ZDOTI = ZDOT(I)
      ZDOT(I) = AI(3)*UU+AI(6)*VV+AI(9)*WW
C (28),(29)
      CS = S1/C2
      CC = C1/C2
      PHDOTI = PHIDOT(I)
      PHIDOT(I) = PP+QQ*CS*S2+RR*CC*S2
      THDOTI = THEDOT(I)
      THEDOT(I) = QQ*C1-RR*S1
      PSDOTI = PSIDOT(I)
      PSIDOT(I) = QQ*CS+RR*CC
C     CODE TO STATEMENT #9 PROVIDES LONGITUDINAL SYMMETRY
      IF(JK.GT.20) GO TO 9
      IF(I.NE.NSYM(JK)) GO TO 9
      JK=JK+1
      YDOT(I)=0.
      PHIDOT(I)=0.
      PSIDOT(I)=0.
      PP=0.
      RR=0.
      P(I)=0.
      R(I)=0.
      RDOT(I)=0.
      PDOT(I)=0.
      VDOT(I)=0.
      YACC(I)=0.
    9 CONTINUE
C DO AIDOT NOW
      T = PSIDOT(I)*C2
      T1 = THEDOT(I)*S1-T*C1
      T2 = THEDOT(I)*C1+T*S1
      T3 = PHIDOT(I)-PSIDOT(I)*S2
      CIJ(J+1)= -BIJ(J+4)*T1-BIJ(J+7)*T2
      CIJ(J+4)=  BIJ(J+1)*T1+BIJ(J+7)*T3
      CIJ(J+7)=  BIJ(J+1)*T2-BIJ(J+4)*T3
      CIJ(J+2)= -BIJ(J+5)*T1-BIJ(J+8)*T2
      CIJ(J+5)=  BIJ(J+2)*T1+BIJ(J+8)*T3
      CIJ(J+8)=  BIJ(J+2)*T2-BIJ(J+5)*T3
      CIJ(J+3)= -BIJ(J+6)*T1-BIJ(J+9)*T2
      CIJ(J+6)=  BIJ(J+3)*T1+BIJ(J+9)*T3
      CIJ(J+9)=  BIJ(J+3)*T2-BIJ(J+6)*T3
      IF(TIME) 10,10,5
C CORRECT X,Y,Z,PHI,THETA,PSI
    5 X(I) = TT*X(I)+ET*(XOLD(I)+DTHALF*(XDOT(I)+XDOTI))
      Y(I) = TT*Y(I)+ET*(YOLD(I)+DTHALF*(YDOT(I)+YDOTI))
      Z(I) = TT*Z(I)+ET*(ZOLD(I)+DTHALF*(ZDOT(I)+ZDOTI))
      PHI(I) = TT*PHI(I)+ET*(PHIOLD(I)+DTHALF*(PHIDOT(I)+PHDOTI))
      THETA(I) = TT*THETA(I)+ET*(THEOLD(I)+DTHALF*(THEDOT(I)+THDOTI))
      PSI(I) = TT*PSI(I)+ET*(PSIOLD(I)+DTHALF*(PSIDOT(I)+PSDOTI))
C CLEAR THE DAMPING TERMS.
      DPX(I) = 0.0
      DPY(I) = 0.0
      DPZ(I) = 0.0
      DPL(I) = 0.0
      DPM(I) = 0.0
      DPN(I) = 0.0
   10 CONTINUE
C DO 1000 IS MAIN DO LOOP TO GET TOTAL INTERNAL FORCES AND MOMENTS
      ILAST = 0
      IJLIJ = 0
```

```
      IJKLIJ = -36
      ID=1
      DO 1000 IJ = 1,IGS
      IJKLIJ = IJKLIJ+36
      IJKK = IJKLIJ-6
      IJLIJ = IJLIJ+6
      IJL = IJLIJ
      IF(IRUPSW(IJ).NE.0) GO TO 900
      GO TO 910
  900 IF(ABS(ISDF(ID)).EQ.IJ) ID=ID+1
      GO TO 1000
  910 I= IG(IJ)
      J = JG(IJ)
C IF WE GET TO A NEW I WE MUST MOVE (AI) INTO AI AND (AIDOT) INTO AIDOT
      IF(I.EQ.ILAST) GO TO 30
   20 ILAST = I
      IS = 9*(I-1)
      DO 320 KS = 1,9
      IS = IS+1
      AIDOT(KS) = CIJ(IS)
      DAI(KS) = OAI(IS)-BIJ(IS)
  320 AI(KS) = AIJ(IS)
   30 XIJ = X(J)-X(I)
      YIJ = Y(J)-Y(I)
      ZIJ = Z(J)-Z(I)
      XIJO = OXIJ(IJ)
      YIJO = OYIJ(IJ)
      ZIJO = OZIJ(IJ)
      OXIJ(IJ) = XIJ
      OYIJ(IJ) = YIJ
      OZIJ(IJ) = ZIJ
C
      IS = 9*(J-1)
      IJS = 9*(IJ-1)
      DO 310 KS = 1,9
      IS = IS+1
      IJS = IJS+1
      AIJ(KS) = DIJ(IJS)
  310 AJ(KS) = AIJ(IS)
C (4) INCREMENTAL DEFLECTION GRD AXES
      T1 = DX(J)-DX(I)
      T2 = DY(J)-DY(I)
      T3 = DZ(J)-DZ(I)
      DXD(1)=T1
      DXD(2)=T2
      DXD(3)=T3
C (5) TRANSFORM TO BEAM AXES
      T4= AI(1)*T1+AI(2)*T2+AI(3)*T3-DAI(1)*XIJO-DAI(2)*YIJO-DAI(3)*ZIJO
      T5= AI(4)*T1+AI(5)*T2+AI(6)*T3-DAI(4)*XIJO-DAI(5)*YIJO-DAI(6)*ZIJO
      T6= AI(7)*T1+AI(8)*T2+AI(9)*T3-DAI(7)*XIJO-DAI(8)*YIJO-DAI(9)*ZIJO
      D(1) = AIJ(1)*T4+AIJ(2)*T5+AIJ(3)*T6
      D(2) = AIJ(4)*T4+AIJ(5)*T5+AIJ(6)*T6
      D(3) = AIJ(7)*T4+AIJ(8)*T5+AIJ(9)*T6
C     COMPUTE CHORD ANGLES IN GRD AXES
      IF(YIJ.NE.0.)GO TO 2140
      IF(XIJ.EQ.0.) GO TO 2170
      YAW=0.0
      PITCH=-ATAN2(ZIJ,XIJ)
      GO TO 2200
 2170 YAW=0.0
      PITCH=-PI2
      IF(ZIJ.GE.0.) GO TO 2200
      PITCH=PI2
      GO TO 2200
 2140 YAW=ATAN2(YIJ,XIJ)
      PITCH=-ATAN2(ZIJ,SQRT(XIJ*XIJ+YIJ*YIJ))
 2200 CONTINUE
C OLD AXIAL LOAD TO GRD AXES
      SS2=SIN(PTHO(IJ))
      CC2=COS(PTHO(IJ))
      SS3=SIN(YAWO(IJ))
      CC3=COS(YAWO(IJ))
         IF(ABS(PITCH).LT.1.E-10) PITCH= ZERO
```

```
        IF(ABS(YAW).LT.1.E-10) YAW= ZERO                               0256
        IF(ABS(SS2).LT.1.E-10) SS2= ZERO                               0256
        IF(ABS(SS3).LT.1.E-10) SS3= ZERO                               0256
        IF(ABS(CC2).LT.1.E-10) CC2= ZERO                               0256
        IF(ABS(CC3).LT.1.E-10) CC3= ZERO                               0256
      NAN=(IJ-1)*36+1
      FDX=DELFMO(NAN)*CC2*CC3
      FDY=DELFMO(NAN)*CC2*SS3
      FDZ=-DELFMO(NAN)*SS2
C     STORE PITCH AND YAW
      PTHO(IJ)=PITCH
      YAWO(IJ)=YAW
C     COMPUTE GRD TO CHORD 'AI'
      S2=SIN(PITCH)
      C2=COS(PITCH)
      S3=SIN(YAW)
      C3=COS(YAW)
      DO 1060  KA=3,6
 1060   IF(ABS(SINCOS(KA)).LT.1.E-10) SINCOS(KA)= ZERO                 0270
      RP(1)=C2*C3
      RP(2)=C2*S3
      RP(3)=-S2
C     COMPUTE CHORD COMPONENTS     D(1) ONLY REQUIRED
C     TRANSFORM INCREMENTAL DEFECT   GRD TO CHORDAXES
      D(1)=RP(1)*DXD(1)+RP(2)*DXD(2)+RP(3)*DXD(3)
C (9)                                                                  0191
      AITAJ(1) = AI(1)*AJ(1)+AI(2)*AJ(2)+AI(3)*AJ(3)                   0192
      AITAJ(2) = AI(4)*AJ(1)+AI(5)*AJ(2)+AI(6)*AJ(3)                   0193
      AITAJ(3) = AI(7)*AJ(1)+AI(8)*AJ(2)+AI(9)*AJ(3)                   0194
      AITAJ(4) = AI(1)*AJ(4)+AI(2)*AJ(5)+AI(3)*AJ(6)                   0195
      AITAJ(5) = AI(4)*AJ(4)+AI(5)*AJ(5)+AI(6)*AJ(6)                   0196
      AITAJ(6) = AI(7)*AJ(4)+AI(8)*AJ(5)+AI(9)*AJ(6)                   0197
      AITAJ(7) = AI(1)*AJ(7)+AI(2)*AJ(8)+AI(3)*AJ(9)                   0198
      AITAJ(8) = AI(4)*AJ(7)+AI(5)*AJ(8)+AI(6)*AJ(9)                   0199
      AITAJ(9) = AI(7)*AJ(7)+AI(8)*AJ(8)+AI(9)*AJ(9)                   0200
      T1 = DPIN(J)                                                     0201
      T2 = DQIN(J)                                                     0202
      T3 = DRIN(J)                                                     0203
      T4 = T1*AITAJ(1)+T2*AITAJ(4)+T3*AITAJ(7)-DPIN(I)                 0204
      T5 = T1*AITAJ(2)+T2*AITAJ(5)+T3*AITAJ(8)-DQIN(I)                 0205
      T6 = T1*AITAJ(3)+T2*AITAJ(6)+T3*AITAJ(9)-DRIN(I)                 0206
C (9R)                                                                 0207
      D(4) = AIJ(1)*T4+AIJ(2)*T5+AIJ(3)*T6                             0208
      D(5) = AIJ(4)*T4+AIJ(5)*T5+AIJ(6)*T6                             0209
      D(6)= AIJ(7)*T4+AIJ(8)*T5+AIJ(9)*T6                              0210
      DD(1)=D(1)/DELTAT
      DD(2)=D(2)/DELTAT
       DD(3)=D(3)/DELTAT
      T1 = P(J)                                                        0220
      T2 = Q(J)                                                        0221
      T3 = R(J)                                                        0222
      T4 = T1*AITAJ(1)+T2*AITAJ(4)+T3*AITAJ(7)-P(I)                    0223
      T5 = T1*AITAJ(2)+T2*AITAJ(5)+T3*AITAJ(8)-Q(I)                    0224
      T6 = T1*AITAJ(3)+T2*AITAJ(6)+T3*AITAJ(9)-R(I)                    0225
      DD(4) = T4*AIJ(1)+T5*AIJ(2)+T6*AIJ(3)                            0226
      DD(5) = T4*AIJ(4)+T5*AIJ(5)+T6*AIJ(6)                            0227
      DD(6) = T4*AIJ(7)+T5*AIJ(8)+T6*AIJ(9)                            0228
      DO 270 K = 1,6                                                   0229
  270 DD(K) = C(K,IJ)*DD(K)                                            0230
C*****DVSIGN IS NO LONGER USED.                                        0231
C*****FMBAR HAS VRBAR(I,J,K,L) IN IT NOW (7AUG1972)                    0232
C***** LOOP 150  INCREMENTAL FORCE IN BEAMS ******
C     LOOP 150 REVISED TO PROVIDE HYSTERISIS- PIECEWISE LINEAR FORCE
C     DEFLECTION CURVES USED.
C     DEFLECTION MUST BE COMPUTED AT LEAST ONCE ON EACH LEG OF LOAD CYCLE
C    ASSUMED....,T=0,XKREF(L,IJ)=0,VEE(IJL)=0,FMBAR(L,IJ)=0
C     VEE(IJL)= OLD DEFLECTION
C     A=INCREMENTAL DEFLECTION
C   B=NEW DEFLECTION RELATIVE TO CURRENT ORIGIN
C    XKREF(L,IJ)=CURRENT ORIGIN OF FORCE -DEFLECTION CURVE
```

```
C     DELFMO(IJKL)= OLD FORCE FOR K,L PRODUCT
C   FMBAR(L,IJ)= MAX STROKE ON CURRENT LOAD CYCLE
C     XKD=SPRINGBACK DEFLECTION TO ZERO FORCE
C     XKS(PTR)= SLOPE FACTOR BETWEEN XKR(PTR) AND XKR(PTR+1)
      YIELD(IJ,1)=BLANK
      DO 150 K = 1,6
      IJKK = IJKK+6
      DELFM=0.
      IJKL = IJKK
      IJL = IJL-6
      DF(K) = 0.0
      DO 150 L = 1,6
      IJKL = IJKL+1
      IJL = IJL+1
      T = XK(IJKL)
      IF(T.EQ.0.0) GO TO 150
  160 A = D(L)
      B=A+VEE(IJL)-XKREF(L,IJ)
      ITN=NLSFLG(IJL)
      ICH=(ITN-1)*10+1
C     CHECK FOR TABLES
C     IF(ITN.EQ.0)  LINEAR FORCE
      IF(ITN.EQ.0)  GO TO 195
C     CHECK FOR LOAD OR UNLOAD
      IF(B.EQ.0.0.AND.XKREF(L,IJ).EQ.0.0) GO TO 195
      IF(A.GT.0..AND.B.LT.0..OR.A.LT.0..AND.B.GT.0.)   GO TO 211
C     LOAD CYCLE RELATIVE TO CURRENT ORIGIN  A-B-C ORD-E-F
C     CHECK FOR RELOADING ALONG C-D OR G-F
      IF(ABS(B).LT.ABS(FMBAR(L,IJ))) GO TO 180
C     FIND CHUG(ITN)
  210 AXK=ABS(B)
      PTR=CHUG(ITN)
      IF(AXK.LE.XKR(PTR))  GO TO 120
  110 PTR=PTR+1
      IF(AXK.GT.XKR(PTR)) GO TO 110
      PTR=PTR-1
      CHUG(ITN)=PTR
      NXX=PTR-1
      GO TO 140
  120 PTR=PTR-1
      IF(AXK.LT.XKR(PTR)) GO TO 120
      PTR=PTR+1
      CHUG(ITN)=PTR
      NXX=PTR-1
C     CHECK FOR A-B-C OR D-E-F
  140 ICHX=CHUG(ITN)
      IF(ICHX.GT.ICH) YIELD(IJ,1)=ASTRIC
      IF(ICHX.GT.ICH) PLAST(IJ,1)=ASTRIC
      IF(B.LT.0.) GO TO 190
C     COMPUTE NEW FORCE
      DELFM=(B-XKR(PTR))*T*XKS(PTR)
      IF(ICH.EQ.NXX+1) GO TO 143
      DO 142 NX=ICH,NXX
      NXN=NX+1
  142 DELFM=DELFM+(XKR(NXN)-XKR(NX))*T*XKS(NX)
  143 DTEMP=DELFM
C     COMPUTE INCREMENT AND SAVE NEW FORCE
      DELFM=DELFM-DELFMO(IJKL)
      DELFMO(IJKL)=DTEMP
C     CHECK FOR NEW MAX STROKE AND SET PLASTIC INDICATOR
      IF(B.GT.FMBAR(L,IJ).AND.DTEMP.GT.0.0.OR.B.LT.FMBAR(L,IJ)
     1 .AND.DTEMP.LT.0.0) FMBAR(L,IJ)=B
      GO TO 220
  211 CONTINUE
C     UNLOADING ON C-D OR G-F  FIRST CHECK FOR NEW ORIGIN
      XKD=DELFMO(IJKL)/T
      DTEMP=VEE(IJL)-XKREF(L,IJ)-XKD
      IF(B.LT.DTEMP.AND.DELFMO(IJKL).GT.0.0.OR.B.GT.DTEMP.AND.
     1DELFMO(IJKL).LT.0.0) GO TO 152
C     UNLOADING LINEAR
```

```
      DELFM=DELFMO(IJKL)+T*A
      YIELD(IJ,1)=BLANK
      GO TO 143
  195 CONTINUE
C     LINEAR ELEMENT
      DELFM=T*A
      DELFMO(IJKL)=DELFMO(IJKL)+DELFM
      GO TO 220
  152 CONTINUE
C     CROSSED AXIS, RESET ORIGIN,MAX STROKE, THEN RELOAD
      XKREF(L,IJ)=VEE(IJL)-XKD
      B=A+VEE(IJL)-XKREF(L,IJ)
      FMBAR(L,IJ)=B
      CHUG(ITN)=ICH
      GO TO 210
  180 CONTINUE
C     RELOADING ON C-D OR G-F
      DELFM=DELFMO(IJKL)+T*A
      YIELD(IJ,1)=BLANK
      GO TO 143
  190 CONTINUE
C     LOADING ON D-E-F
      DELFM=-(ABS(B)-XKR(PTR))*XKS(PTR)*T
      IF(ICH.EQ.NXX+1) GO TO 143
      DO 191 NX=ICH,NXX
      NXN=NX+1
  191 DELFM=DELFM-(XKR(NXN)-XKR(NX))*T*XKS(NX)
      GO TO 143
  220 DF(K)=DF(K)+DELFM
  230 CONTINUE
      DO 630 K = 1,6                                                   0279
      SIGF(K,IJ)=SUMDF(K,IJ)                                           0279
  630 SUMDF(K,IJ) = SUMDF(K,IJ) + DF(K)                                0280
C     THIS IS A TEST FOR COMPRESSION OR TENSION IN BEAMS SPECIFIED
C     BY INPUT ARRAY ISDF(40)
      IF(TIME.EQ.0.0.OR.ID.GT.40.OR.ISDF(ID).EQ.0) GO TO 634
      IF(ISDF(ID).GT.0) GO TO 633
      ITEMP=-ISDF(ID)
      IF(IJ.NE.ITEMP) GO TO 634
      SDF(IJ)=SDF(IJ)+DF(1)
      SUMDF(1,IJ)=SDF(IJ)
      IF(SDF(IJ).GE.0.0.AND.SUMDF(1,IJ).GE.0.0) GO TO 620
      GO TO 621
  633 IF(IJ.NE.ISDF(ID)) GO TO 634
      SDF(IJ)=SDF(IJ)+DF(1)
      SUMDF(1,IJ)=SDF(IJ)
      IF(SDF(IJ).LE.0.0.AND.SUMDF(1,IJ).LE.0.0) GO TO 620
  621 SUMDF(1,IJ)=0.0
      DF(1)=0.0
      DO 623 K=1,6
         DD(K)=0.0
  623 CONTINUE
  620 ID=ID+1
C*****COMPUTE THE ENERGY HERE BUT ADD IT AFTER 230 (NO RUPTURES)      0281
  634 SUMSE=0.0
      SUMDE=0.0                                                        0281
C***** DON'T USE AN IJ IF IT'S A DRI ELEMENT                           0281
      IF(IJPR(IJ).NE.BLANK)GO TO 632                                   0281
      DO 631 K=1,6                                                     0281
      SUMSE=SUMSE+.5*(SUMDF(K,IJ)+SIGF(K,IJ))*D(K)                     0281
  631 SUMDE=SUMDE+DD(K)*D(K)
C                                                                      0281
C                                                                      0281
C                                                                      0281
  632 IJL= IJL-6                                                       0281
      DO 230 L = 1,6                                                   0282
      IJL = IJL+1                                                      0283
      T = VEE(IJL)+D(L)                                                0284
      VEE(IJL) = T                                                     0285
C MOVE DF TO D FOR (13) ETC.                                           0286
```

```
      D(L) = DF(L)
      IF(T.LT.0.0) T=-T
      IF((LOIS(IJ).EQ.0.AND.T.LT.VMAX(IJL)).OR.IRUPSW(IJ).NE.0)
     1 GO TO 230
C
C               THE FOLOWING CODE DOWN TO STATEMENT # 230 WAS ADDED BY
C               ED W.                                   8-5-76
C               IT IS INCREMENTAL RUPTURE CRITERIA WHICH RUPTURES
C               AN ELEMENT IN 5 STEPS AND CAUSES DECREASE IN TIME
C               INCREMENT TO HANDLE INTEGRATION PROBLEMS
      LOIS(IJ)=LOIS(IJ)+1
      IF(LOIS(IJ).EQ.1) KOUNT=KOUNT+1
      IF(LOIS(IJ).EQ.1) PRINT 265,IJ,I,J,TIME
      XLOIS=LOIS(IJ)
      D(L)=(5.-XLOIS)*.2*D(L)
      IF(LOIS(IJ).LT.5) GO TO 230
  264 IRUPSW(IJ)=I
      XX(I) = XX(I)-XXK(IJ)
      XY(I) = XY(I)-XYK(IJ)
      XZ(I) = XZ(I)-XZK(IJ)
      XL(I) = XL(I)-XLK(IJ)
      XM(I) = XM(I)-XMK(IJ)
      XN(I) = XN(I)-XNK(IJ)
      XX(J) = XX(J)-XXJ(IJ)
      XY(J) = XY(J)-XYJ(IJ)
      XZ(J) = XZ(J)-XZJ(IJ)
      XL(J) = XL(J)-XLJ(IJ)
      XM(J) = XM(J)-XMJ(IJ)
      XN(J) = XN(J)-XNJ(IJ)
      KRUPT = KRUPT+1
      IRUPT(KRUPT) = I
      JRUPT(KRUPT) = J
      TRUPT(KRUPT) = TIME
      PRINT 1040,TIME,IJ,I,J,L,VEE(IJL),VMAX(IJL)
      KOUNT=KOUNT-1
      GO TO 1000
  230 CONTINUE
      SEIJ(IJ) = SEIJ(IJ) + SUMSE
      IF(YIELD(IJ,1).NE.ASTRIC) DEIJ(IJ)=DEIJ(IJ)+SUMDE
 9876 IF(IJPR(IJ).NE.BLANK) DRI(IJ)=-6.55D0*VEE(IJL-5)
C     LOADS AT J<<<<<< BEAM TO GRD AXES
      AIAIJT(1) = AI(1)*AIJ(1)+AI(4)*AIJ(2)+AI(7)*AIJ(3)
      AIAIJT(4) = AI(1)*AIJ(4)+AI(4)*AIJ(5)+AI(7)*AIJ(6)
      AIAIJT(7) = AI(1)*AIJ(7)+AI(4)*AIJ(8)+AI(7)*AIJ(9)
      AIAIJT(2) = AI(2)*AIJ(1)+AI(5)*AIJ(2)+AI(8)*AIJ(3)
      AIAIJT(5) = AI(2)*AIJ(4)+AI(5)*AIJ(5)+AI(8)*AIJ(6)
      AIAIJT(8) = AI(2)*AIJ(7)+AI(5)*AIJ(8)+AI(8)*AIJ(9)
      AIAIJT(3) = AI(3)*AIJ(1)+AI(6)*AIJ(2)+AI(9)*AIJ(3)
      AIAIJT(6) = AI(3)*AIJ(4)+AI(6)*AIJ(5)+AI(9)*AIJ(6)
      AIAIJT(9) = AI(3)*AIJ(7)+AI(6)*AIJ(8)+AI(9)*AIJ(9)
C (13A)
      OXD(1)=D(1)
      D(1)=0.
      T1 = AIAIJT(1)*D(1)+AIAIJT(4)*D(2)+AIAIJT(7)*D(3)
      T2 = AIAIJT(2)*D(1)+AIAIJT(5)*D(2)+AIAIJT(8)*D(3)
      T3 = AIAIJT(3)*D(1)+AIAIJT(6)*D(2)+AIAIJT(9)*D(3)
C     DELTA AXIAL FORCE COMPONENTS    GRD AXES
      FDY=DELFMO(NAN)*C2*S3-FDY
      FDX=DELFMO(NAN)*C2*C3-FDX
      FDZ=-DELFMO(NAN)*S2-FDZ
      D(1)=T1
      D(2)=T2
      D(3)=T3
C (13B)
      T1 = AIAIJT(1)*D(4)+AIAIJT(4)*D(5)+AIAIJT(7)*D(6)
      T2 = AIAIJT(2)*D(4)+AIAIJT(5)*D(5)+AIAIJT(8)*D(6)
      T3 = AIAIJT(3)*D(4)+AIAIJT(6)*D(5)+AIAIJT(9)*D(6)
      D(4) = T1
      D(5) = T2
      D(6) = T3
```

```
C       GRD AXES TO MASS
        D(1)=D(1)+FDX
        D(2)=D(2)+FDY
        D(3)=D(3)+FDZ
C (17A)                                                         0337
        DXX = -(AJ(1)*D(1)+AJ(2)*D(2)+AJ(3)*D(3))               0338
        DXY = -(AJ(4)*D(1)+AJ(5)*D(2)+AJ(6)*D(3))               0339
        DXZ = -(AJ(7)*D(1)+AJ(8)*D(2)+AJ(9)*D(3))               0340
        XX(J) = XX(J)+DXX                                       0341
        XY(J) = XY(J)+DXY                                       0342
        XZ(J) = XZ(J)+DXZ                                       0343
        XXJ(IJ) = XXJ(IJ)+DXX                                   0344
        XYJ(IJ) = XYJ(IJ)+DXY                                   0345
        XZJ(IJ) = XZJ(IJ)+DXZ                                   0346
C (17B)                                                         0347
        DXL = -(AJ(1)*D(4)+AJ(2)*D(5)+AJ(3)*D(6))               0348
        DXM = -(AJ(4)*D(4)+AJ(5)*D(5)+AJ(6)*D(6))               0349
        DXN = -(AJ(7)*D(4)+AJ(8)*D(5)+AJ(9)*D(6))               0350
        XL(J) = XL(J)+DXL                                       0351
        XM(J) = XM(J)+DXM                                       0352
        XN(J) = XN(J)+DXN                                       0353
        XLJ(IJ) = XLJ(IJ)+DXL                                   0354
        XMJ(IJ) = XMJ(IJ)+DXM                                   0355
        XNJ(IJ) = XNJ(IJ)+DXN                                   0356
        IF (IJPR(IJ).NE.BLANK)  GO TO 700                       0357
C (14B)                                                         0358
C        CHECKING FOR PINNED BEAMS 1-8-76
        IF(PN(IJ).NE.0.0) GO TO 699
        D(4) = D(4) - ZIJ*D(2) + YIJ*D(3)
        D(5) = D(5) + ZIJ*D(1) - XIJ*D(3)
        D(6) = D(6) - YIJ*D(1) + XIJ*D(2)
C (16A)                                                         0362
  699 CONTINUE
        DXX = AI(1)*D(1)+AI(2)*D(2)+AI(3)*D(3)                  0363
        DXY = AI(4)*D(1)+AI(5)*D(2)+AI(6)*D(3)                  0364
        DXZ = AI(7)*D(1)+AI(8)*D(2)+AI(9)*D(3)                  0365
        XX(I) = XX(I)+DXX                                       0366
        XY(I) = XY(I)+DXY                                       0367
        XZ(I) = XZ(I)+DXZ                                       0368
        XXK(IJ) = XXK(IJ)+DXX                                   0369
        XYK(IJ) = XYK(IJ)+DXY                                   0370
        XZK(IJ) = XZK(IJ)+DXZ                                   0371
C (16B)                                                         0372
        DXL = AI(1)*D(4)+AI(2)*D(5)+AI(3)*D(6)                  0373
        DXM = AI(4)*D(4)+AI(5)*D(5)+AI(6)*D(6)                  0374
        DXN = AI(7)*D(4)+AI(8)*D(5)+AI(9)*D(6)                  0375
        XL(I) = XL(I)+DXL                                       0376
        XM(I) = XM(I)+DXM                                       0377
        XN(I) = XN(I)+DXN                                       0378
        XLK(IJ) = XLK(IJ)+DXL                                   0379
        XMK(IJ) = XMK(IJ)+DXM                                   0380
        XNK(IJ) = XNK(IJ)+DXN                                   0381
C (6A)                                                          0382
  700 CONTINUE  *                                               0383
C       IF DAMPING=0 BYPASS TO 272
        IF(YIELD(IJ,1).EQ.ASTRIC.OR.C(1,IJ).EQ.0.) GO TO 272
        T1 = AIAIJT(1)*DD(1)+AIAIJT(4)*DD(2)+AIAIJT(7)*DD(3)    0384
        T2 = AIAIJT(2)*DD(1)+AIAIJT(5)*DD(2)+AIAIJT(8)*DD(3)    0385
        T3 = AIAIJT(3)*DD(1)+AIAIJT(6)*DD(2)+AIAIJT(9)*DD(3)    0386
        DD(1) = T1                                              0387
        DD(2) = T2                                              0388
        DD(3) = T3                                              0389
C (6B)                                                          0390
        T1 = AIAIJT(1)*DD(4)+AIAIJT(4)*DD(5)+AIAIJT(7)*DD(6)    0391
        T2 = AIAIJT(2)*DD(4)+AIAIJT(5)*DD(5)+AIAIJT(8)*DD(6)    0392
        T3 = AIAIJT(3)*DD(4)+AIAIJT(6)*DD(5)+AIAIJT(9)*DD(6)    0393
        DD(4) = T1                                              0394
        DD(5) = T2                                              0395
        DD(6) = T3                                              0396
C (9A)                                                          0397
```

```
      DXX = -(AJ(1)*DD(1)+AJ(2)*DD(2)+AJ(3)*DD(3))
      DXY = -(AJ(4)*DD(1)+AJ(5)*DD(2)+AJ(6)*DD(3))
      DXZ = -(AJ(7)*DD(1)+AJ(8)*DD(2)+AJ(9)*DD(3))
      DPX(J) = DPX(J)+DXX
      DPY(J) = DPY(J)+DXY
      DPZ(J) = DPZ(J)+DXZ
C (9B)
      DXL = -(AJ(1)*DD(4)+AJ(2)*DD(5)+AJ(3)*DD(6))
      DXM = -(AJ(4)*DD(4)+AJ(5)*DD(5)+AJ(6)*DD(6))
      DXN = -(AJ(7)*DD(4)+AJ(8)*DD(5)+AJ(9)*DD(6))
      DPL(J) = DPL(J)+DXL
      DPM(J) = DPM(J)+DXM
      DPN(J) = DPN(J)+DXN
      IF (IJPR(IJ).NE.BLANK)  GO TO 1000
C (7)
C      CHECKING FOR PINNED BEAMS 1-8-76
      IF(PN(IJ).NE.0.0) GO TO 2120
      DD(4) = DD(4) - ZIJ*DD(2)  + YIJ*DD(3)
      DD(5) = DD(5) + ZIJ*DD(1)  - XIJ*DD(3)
      DD(6) = DD(6) - YIJ*DD(1)  + XIJ*DD(2)
C (8A)
 2120 CONTINUE
      DXX = AI(1)*DD(1)+AI(2)*DD(2)+AI(3)*DD(3)
      DXY = AI(4)*DD(1)+AI(5)*DD(2)+AI(6)*DD(3)
      DXZ = AI(7)*DD(1)+AI(8)*DD(2)+AI(9)*DD(3)
      DPX(I) = DPX(I)+DXX
      DPY(I) = DPY(I)+DXY
      DPZ(I) = DPZ(I)+DXZ
C (8B)
      DXL = AI(1)*DD(4)+AI(2)*DD(5)+AI(3)*DD(6)
      DXM = AI(4)*DD(4)+AI(5)*DD(5)+AI(6)*DD(6)
      DXN = AI(7)*DD(4)+AI(8)*DD(5)+AI(9)*DD(6)
      DPL(I) = DPL(I)+DXL
      DPM(I) = DPM(I)+DXM
      DPN(I) = DPN(I)+DXN
  272 CONTINUE
 1000 CONTINUE
      IS=9*(INDP-1)
      DO 1010 KS=1,9
      IS=IS+1
 1010 AP(KS)=BIJ(IS)
C FINISH COMPUTING DERIVATIVES
      DO 2000 I=1,NM
      IS = 9*(I-1)
      DO 330 KS = 1,9
      IS = IS+1
      AIDOT(KS) = CIJ(IS)
  330 AI(KS) = AIJ(IS)
C DO CRASH FORCES
      DO 340 K = 1,6
  340 XC(K) = 0.0
      IF(ISP(I,1).EQ.1 .OR.ISP(I,2).EQ.1.OR.ISP(I,3).EQ.1) CALL CFORCE
C (20),(23),(24)
      XA = WGT(I)-ALIFT(I)
      SX = XX(I)+XA*AI(3)+XC(1)+DPX(I)
      SY = XY(I)+XA*AI(6)+XC(2)+DPY(I)
      SZ = XZ(I)+XA*AI(9)+XC(3)+DPZ(I)
      SL = XL(I)+XC(4)+DPL(I)
      SM = XM(I)+XC(5)+DPM(I)
      SN = XN(I)+XC(6)+DPN(I)
C GET P,Q,R,U,V,W
      PP = P(I)
      QQ = Q(I)
      RR = R(I)
      UU = U(I)
      VV = V(I)
      WW = W(I)
C MASS
      WGTI = 1.0/WGT(I)
      ZM = 386.0*WGTI
```

```
      XACC(I) = SX*WGTI
      YACC(I) = SY*WGTI
      ZACC(I) = SZ*WGTI
C (25)
      UDOTI = UDOT(I)
      UDOT(I) = SX*ZM-QQ*WW+RR*VV
      VDOTI = VDOT(I)
      VDOT(I) = SY*ZM-RR*UU+PP*WW
      WDOTI = WDOT(I)
      WDOT(I) = SZ*ZM-PP*VV+QQ*UU
C (26)
      T1 = -XZI(I)*PP-YZI(I)*QQ+ZI(I)*RR+HEZ(I)
      T2 = XI(I)*PP-XYI(I)*QQ-XZI(I)*RR+HEX(I)
      T3 = -XYI(I)*PP+YI(I)*QQ-YZI(I)*RR+HEY(I)
      SL = SL-QQ*T1+RR*T3
      SM = SM-RR*T2+PP*T1
      SN = SN-PP*T3+QQ*T2
C (25)
      DEL = DELT(I)
      PDOTI = PDOT(I)
      PDOT(I) = DEL*(SL*XI1(I)+SM*XI2(I)+SN*XI3(I))
      QDOTI = QDOT(I)
      QDOT(I) = DEL*(SL*XI2(I)+SM*XI5(I)+SN*XI4(I))
      RDOTI = RDOT(I)
      RDOT(I) = DEL*(SL*XI3(I)+SM*XI4(I)+SN*XI6(I))
      IF(TIME) 2000,2000,380
  380 IF(ABS(UDOT(I)).GT.0.) TEST1=ABS((XACC(I)*386.-UDOT(I))/UDOT(I))
      IF(TEST1.GT.TMX)TMX=TEST1
      IF(ABS(WDOT(I)).GT.0.) TEST1=ABS((ZACC(I)*386.-WDOT(I))/WDOT(I))
      IF(TEST1.GT.TMX)TMX=TEST1
      IF(ABS(UDOT(I)).GT.TTMX)TTMX=ABS(UDOT(I))
      IF(ABS(WDOT(I)).GT.TTMX)TTMX=ABS(WDOT(I))
      IF(ABS(QDOT(I)).GT.TTTMX) TTTMX=ABS(QDOT(I))
      IF(I.EQ.NSYM(JL)) GO TO 381
      IF(ABS(PDOT(I)).GT.TTTMX) TTTMX=ABS(PDOT(I))
      IF(ABS(RDOT(I)).GT.TTTMX) TTTMX=ABS(RDOT(I))
      IF(ABS(VDOT(I)).GT.TTMX)TTMX=ABS(VDOT(I))
      IF(ABS(VDOT(I)).GT.0.) TEST1=ABS((YACC(I)*386.-VDOT(I))/VDOT(I))
      IF(TEST1.GT.TMX)TMX=TEST1
  381 CONTINUE
  300 U(I) = TT*U(I)+ET*(UOLD(I)+DTHALF*(UDOT(I)+UDOTI))
      V(I) = TT*V(I)+ET*(VOLD(I)+DTHALF*(VDOT(I)+VDOTI))
      W(I) = TT*W(I)+ET*(WOLD(I)+DTHALF*(WDOT(I)+WDOTI))
      P(I) = TT*P(I)+ET*(POLD(I)+DTHALF*(PDOT(I)+PDOTI))
      Q(I) = TT*Q(I)+ET*(QOLD(I)+DTHALF*(QDOT(I)+QDOTI))
      R(I) = TT*R(I)+ET*(ROLD(I)+DTHALF*(RDOT(I)+RDOTI))
      PIN(I) = TT*PIN(I)+ET*(PINO(I)+DTHALF*(P(I)+POLD(I)))
      QIN(I) = TT*QIN(I)+ET*(QINO(I)+DTHALF*(Q(I)+QOLD(I)))
      RIN(I) = TT*RIN(I)+ET*(RINO(I)+DTHALF*(R(I)+ROLD(I)))
C     CODE TO STATEMENT #2001 PROVIDES LONGITUDINAL SYMMETRY
      IF(JL.GT.20) GO TO 2001
      IF(I.NE.NSYM(JL)) GO TO 2001
      JL=JL+1
      VDOT(I)=0.
      V(I)=0.
      PHI(I)=0.
      P(I)=0.0
      R(I)=0.
      PIN(I)=0.
      RIN(I)=0.
      PDOT(I)=0.
      RDOT(I)=0.
 2001 CONTINUE
      IF ((IPENSW(I).NE.0).OR.(I.EQ.INDP).OR.(INDP.EQ.0))  GO TO 2000
C
C        CONTROL VOLUME PENETRATION CALCULATIONS
C
      TP1=X(I)-X(INDP)
      TP2=Y(I)-Y(INDP)
      TP3=Z(I)-Z(INDP)
```

```
      XPI=AP(1)*TP1+AP(2)*TP2+AP(3)*TP3
      YPI=AP(4)*TP1+AP(5)*TP2+AP(6)*TP3
      ZPI=AP(7)*TP1+AP(8)*TP2+AP(9)*TP3
      IF ((-XNBAR.GT.XPI).OR.(XPI.GT.XPBAR))  GO TO 2000
      IF ((-YNBAR.GT.YPI).OR.(YPI.GT.YPBAR))  GO TO 2000
      IF ((-ZNBAR.GT.ZPI).OR.(ZPI.GT.ZPBAR))  GO TO 2000
      KPEN=KPEN+1
      IPEN(KPEN)=I
      TPEN(KPEN)=TIME
      IPENSW(I)=1
      PRINT 1080, I,TIME
 1080 FORMAT(1H0,' CONTROL VOLUME PENETRATED BY MASS ',I2,' TIME=',
     1 F10.5)
 2000 CONTINUE
      IF(KOUNT.NE.0) GO TO 2004
      IF(TIME.LE.0.) GO TO 2004
      IF(TMX.GT.0.) TMX=SQRT(EROT*2./TMX)
      IF(TTMX.GT.0.) TTMX=SQRT(EEQ*2./TTMX)
      IF(TTTMX.GT.0.)TTTMX=SQRT(EER*2./TTTMX )
      DELSV=DELTAT
      DELTAT=TTMX
      IF(TTTMX.LT.TTMX.AND.TTTMX.GT.0.) DELTAT=TTTMX
      IF(TMX.LT.TTMX.AND.TMX.LT.TTTMX.AND.TMX.GT.0.) DELTAT=TMX
      IF((DELTAT/DELSV).GT.2.)DELTAT=2.*DELSV
      IF(DELTAT/DELSV.LT.0.1) DELTAT=0.1*DELSV
      IF(DELTAT.LT.DELTMN)DELTAT=DELTMN
      IF(DELTAT.LE.DELTMN) ERROR=ERROR+1.
 2004 TMX=0.
      TTMX=0.
      TTTMX=0.
  265 FORMAT( 1H1 / ' BEAM ELT NO=' I4 'I=' I4 'J=' I4/
     1 ' RUPTURE AT TIME=' F9.5)
 1040 FORMAT(1H0 ' RUPTURE TIME=' 1PE15.6 4I5 1P2E15.6)
      RETURN
      END
!ASS (M:SO,LO)
!ASS (M:C1,D5,S79RPR;F)


!CUP CI,SO
      SUBROUTINE DOAIJ
      IMPLICIT REAL*8(A-H,O-Z)
C     MEMBER NAME S79RDOAJ
C NOTE FOR DOUBLE PRECISION T TSET IN STATE NO 1050&1075 CCHG TO E10
      DIMENSION SINCOS(6),XTHOLD(9,2),XYZIJI(9),XYZIJJ(9),PROD(9),
     1 XIIJ(3)
      DIMENSION XK3(6,6,085)
      COMMON/RPLA/CBAR(85),XDP(50),YDP(50),ZDP(50)
      COMMON/COMALL/ C(6,085),P(50),Q(50),R(50),U(50),V(50),W(50),X(50),
     1 Y(50),Z(50),AI(9),AJ(9),XKREF(6,85),SC(50,3),XC(6),
     A XK(3060),XI(50),
     2YI(50),ZI(50),XYI(50),XZI(50),YZI(50),AIJ(9),BIJ(450),DIJ(765),
     3 ORI(085),OAI(450),VEE(510),WGT(50),PHI(50),THETA(50),PSI(50),
     4 PDOT(50),QDOT(50),RDOT(50),UDOT(50),VDOT(50),WDOT(50),XDOT(50),
     5 YDOT(50),ZDOT(50),PHIDOT(50),THEDOT(50),PSIDOT(50),TIME,DELTAT,
     6XACC(50),YACC(50),ZACC(50),AITAJ(9),AIDOT(9),FMBAR(6,85),
     A DELFMO(3060),
     7 PHIIJ(085),THEIJ(085),PSIIJ(085),SUMDF(6,085),TITLE(20),
     8 XLBAR(50,3),FSPBAR(50,3),VEEDOT(3,3),DX(50),DY(50),DZ(50),
     8 DPIN(50),DQIN(50),DRIN(50),
     8          SEIJ(085),DEIJ(085),CEIK(50,3), TMAX
      COMMON / ICOMAL/ MAXNM,MAXIGS,MAXTBL,INDP,
     A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085),
     B N(510),NK(50,3),ISP(50,3),IJPR(085),IDPLOT(010)
      EQUIVALENCE (XTHOLD(1,1),XYZIJI(1)),(XTHOLD(1,2),XYZIJJ(1))
      EQUIVALENCE (S1,SINCOS(1)),(C1,SINCOS(2)),(S2,SINCOS(3))
```

```
      EQUIVALENCE (C2,SINCOS(4)),(S3,SINCOS(5)),(C3,SINCOS(6))
      EQUIVALENCE (XK(1),XK3(1,1,1))
      SIN(G)= DSIN(G)
      COS(G)= DCOS(G)
      SQRT(G)= DSQRT(G)
      ABS(G)= DABS(G)
      ARSIN(G)= DARSIN(G)
      ATAN2(F,G)= DATAN2(F,G)
      IOLD=0
      DO 1100 I = 1,NM
      ARG=PHI(I)
      S1=SIN(ARG)
      C1=COS(ARG)
      ARG=THETA(I)
      S2=SIN(ARG)
      C2=COS(ARG)
      ARG=PSI(I)
      S3=SIN(ARG)
      C3=COS(ARG)
      DO 1085 J = 1,6
      IF(ABS(SINCOS(J)).LT.1.E-10)  SINCOS(J)=0.0
 1085 CONTINUE
      J=9*(I-1)
C MOVE AI'S TO OLD AI'S
      DO 1090 JJ = 1,9
 1090 OAI(J+JJ)=BIJ(J+JJ)
      S1S2=S1*S2
      C1S2=C1*S2
      BIJ(J+1)=C2*C3
      BIJ(J+2)=C2*S3
      BIJ(J+3)=-S2
      BIJ(J+4)=-C1*S3+S1S2*C3
      BIJ(J+5)=C1*C3+S1S2*S3
      BIJ(J+6)=S1*C2
      BIJ(J+7)=S1*S3+C1S2*C3
      BIJ(J+8)=-S1*C3+C1S2*S3
      BIJ(J+9)=C1*C2
 1100 CONTINUE
C
      DO 1010 IJ = 1,IGS
      S1 = SIN(PHIIJ(IJ))
      C1 = COS(PHIIJ(IJ))
      S2 = SIN(THEIJ(IJ))
      C2 = COS(THEIJ(IJ))
      S3 = SIN(PSIIJ(IJ))
      C3 = COS(PSIIJ(IJ))
      DO 1040 J = 1,6
      IF(ABS(SINCOS(J)).LT.1.E-10)  SINCOS(J)=0.0
 1040 CONTINUE
      AIJ(1) = C2*C3
      AIJ(2) = C2*S3
      AIJ(3) = -S2
      AIJ(4) = -C1*S3+S1*S2*C3
      AIJ(5) = C1*C3+S1*S2*S3
      AIJ(6) = S1*C2
      AIJ(7) = S1*S3+C1*S2*C3
      AIJ(8) = -S1*C3+C1*S2*S3
      AIJ(9) = C1*C2
      I = 9*(IJ-1)
      DO 1015 J = 1,9
 1015 DIJ(I+J) = AIJ(J)
      CBIJ=CBAR(IJ)
      I = IG(IJ)
      J = JG(IJ)
      IF ((IOLD.NE.0).AND.(I.EQ.IOLD))  GO TO 1120
      IS=9*(I-1)
      DO 1110 JJ = 1,9
      IS=IS+1
 1110 AI(JJ)=BIJ(IS)
 1120 IOLD=I
```

```
      IS=9*(J-1)
      DO 1125 JJ = 1,9
      IS=IS+1
 1125 AJ(JJ) = BIJ(IS)
      AITAJ(1)=AI(1)*AJ(1)+AI(2)*AJ(2)+AI(3)*AJ(3)
      AITAJ(2)=AI(4)*AJ(1)+AI(5)*AJ(2)+AI(6)*AJ(3)
      AITAJ(3)=AI(7)*AJ(1)+AI(8)*AJ(2)+AI(9)*AJ(3)
      AITAJ(4)=AI(1)*AJ(4)+AI(2)*AJ(5)+AI(3)*AJ(6)
      AITAJ(5)=AI(4)*AJ(4)+AI(5)*AJ(5)+AI(6)*AJ(6)
      AITAJ(6)=AI(7)*AJ(4)+AI(8)*AJ(5)+AI(9)*AJ(6)
      AITAJ(7)=AI(1)*AJ(7)+AI(2)*AJ(8)+AI(3)*AJ(9)
      AITAJ(8)=AI(4)*AJ(7)+AI(5)*AJ(8)+AI(6)*AJ(9)
      AITAJ(9)=AI(7)*AJ(7)+AI(8)*AJ(8)+AI(9)*AJ(9)
C
C COMPUTE DAMPING COEFFICIENT MATRIX C
      KKS=I
      DO 1312 KS = 1,2
      IF (KS.EQ.2)  KKS=J
      XTHOLD(1,KS)=XI(KKS)
      XTHOLD(2,KS)=XYI(KKS)
      XTHOLD(3,KS)=XZI(KKS)
      XTHOLD(4,KS)=XYI(KKS)
      XTHOLD(5,KS)=YI(KKS)
      XTHOLD(6,KS)=YZI(KKS)
      XTHOLD(7,KS)=XZI(KKS)
      XTHOLD(8,KS)=YZI(KKS)
 1312 XTHOLD(9,KS)=ZI(KKS)
C
      PROD(1)=AITAJ(1)*XYZIJJ(1)+AITAJ(4)*XYZIJJ(2)+AITAJ(7)*XYZIJJ(3)
      PROD(2)=AITAJ(2)*XYZIJJ(1)+AITAJ(5)*XYZIJJ(2)+AITAJ(8)*XYZIJJ(3)
      PROD(3)=AITAJ(3)*XYZIJJ(1)+AITAJ(6)*XYZIJJ(2)+AITAJ(9)*XYZIJJ(3)
      PROD(4)=AITAJ(1)*XYZIJJ(4)+AITAJ(4)*XYZIJJ(5)+AITAJ(7)*XYZIJJ(6)
      PROD(5)=AITAJ(2)*XYZIJJ(4)+AITAJ(5)*XYZIJJ(5)+AITAJ(8)*XYZIJJ(6)
      PROD(6)=AITAJ(3)*XYZIJJ(4)+AITAJ(6)*XYZIJJ(5)+AITAJ(9)*XYZIJJ(6)
      PROD(7)=AITAJ(1)*XYZIJJ(7)+AITAJ(4)*XYZIJJ(8)+AITAJ(7)*XYZIJJ(9)
      PROD(8)=AITAJ(2)*XYZIJJ(7)+AITAJ(5)*XYZIJJ(8)+AITAJ(8)*XYZIJJ(9)
      PROD(9)=AITAJ(3)*XYZIJJ(7)+AITAJ(6)*XYZIJJ(8)+AITAJ(9)*XYZIJJ(9)
C
      XYZIJJ(1)=PROD(1)*AITAJ(1)+PROD(4)*AITAJ(4)+PROD(7)*AITAJ(7)
      XYZIJJ(2)=PROD(2)*AITAJ(1)+PROD(5)*AITAJ(4)+PROD(8)*AITAJ(7)
      XYZIJJ(3)=PROD(3)*AITAJ(1)+PROD(6)*AITAJ(4)+PROD(9)*AITAJ(7)
      XYZIJJ(4)=PROD(1)*AITAJ(2)+PROD(4)*AITAJ(5)+PROD(7)*AITAJ(8)
      XYZIJJ(5)=PROD(2)*AITAJ(2)+PROD(5)*AITAJ(5)+PROD(8)*AITAJ(8)
      XYZIJJ(6)=PROD(3)*AITAJ(2)+PROD(6)*AITAJ(5)+PROD(9)*AITAJ(8)
      XYZIJJ(7)=PROD(1)*AITAJ(3)+PROD(4)*AITAJ(6)+PROD(7)*AITAJ(9)
      XYZIJJ(8)=PROD(2)*AITAJ(3)+PROD(5)*AITAJ(6)+PROD(8)*AITAJ(9)
      XYZIJJ(9)=PROD(3)*AITAJ(3)+PROD(6)*AITAJ(6)+PROD(9)*AITAJ(9)
      DO 1314 KS = 1,9
 1314 XYZIJI(KS)=XYZIJI(KS)+XYZIJJ(KS)
      PROD(1)=XYZIJI(1)*AIJ(1)+XYZIJI(4)*AIJ(2)+XYZIJI(7)*AIJ(3)
      PROD(2)=XYZIJI(2)*AIJ(1)+XYZIJI(5)*AIJ(2)+XYZIJI(8)*AIJ(3)
      PROD(3)=XYZIJI(3)*AIJ(1)+XYZIJI(6)*AIJ(2)+XYZIJI(9)*AIJ(3)
      PROD(4)=XYZIJI(1)*AIJ(4)+XYZIJI(4)*AIJ(5)+XYZIJI(7)*AIJ(6)
      PROD(5)=XYZIJI(2)*AIJ(4)+XYZIJI(5)*AIJ(5)+XYZIJI(8)*AIJ(6)
      PROD(6)=XYZIJI(3)*AIJ(4)+XYZIJI(6)*AIJ(5)+XYZIJI(9)*AIJ(6)
      PROD(7)=XYZIJI(1)*AIJ(7)+XYZIJI(4)*AIJ(8)+XYZIJI(7)*AIJ(9)
      PROD(8)=XYZIJI(2)*AIJ(7)+XYZIJI(5)*AIJ(8)+XYZIJI(8)*AIJ(9)
      PROD(9)=XYZIJI(3)*AIJ(7)+XYZIJI(6)*AIJ(8)+XYZIJI(9)*AIJ(9)
C
      XIIJ(1)=AIJ(1)*PROD(1)+AIJ(2)*PROD(2)+AIJ(3)*PROD(3)
      XIIJ(2)=AIJ(4)*PROD(4)+AIJ(5)*PROD(5)+AIJ(6)*PROD(6)
      XIIJ(3)=AIJ(7)*PROD(7)+AIJ(8)*PROD(8)+AIJ(9)*PROD(9)
      DO 1020 K = 1,3
 1020 C(K,IJ) = .1018D0*CBIJ*SQRT(XK3(K,K,IJ)*(WGT(I)+WGT(J)))
      DO 1030 K = 4,6
      IF(XIIJ(K-3).LT.0.0) XIIJ(K-3)=0.0
 1030 C(K,IJ)=2.*CBIJ*SQRT(XK3(K,K,IJ)*XIIJ(K-3))
 1010 CONTINUE
      RETURN
      END
!ASS (M:SO,LO)
!ASS (M:CI,D5,S79RTM:F)
```

```
ICUR CI,S0
      SUBROUTINE INPUT
      IMPLICIT REAL*8(A-H,O-Z)
C       MEMBER NAME S79RINPT                                           0002
      INTEGER*4 BLANK                                                  0003
      REAL*8 LBAR,MU,KE                                                0004
      REAL*4 KR(15),SLOPE,XKS,XKI,XKR,CHUG                             0006
      DIMENSION VMAX2(6,085)                                           0005
      DIMENSION XK3(6,6,085)                                           0005
      COMMON/PLOT1/ NOPLOT,NMPT(5,40),ISCALE(5),KTYPE(5),NPTC,KPLT
      COMMON/ STITLE/ SUBI(5,20),PLTT
      COMMON/IPT/INPAP,IPAP
      COMMON/RPLA/CBAR(85),XDP(50),YDP(50),ZDP(50)
      COMMON/PNAS/PN(85)
      COMMON/VARSTP/ DELTMN,DELSV,EER,EEQ,EROT,ERROR
     1,TMX,TTMX,TTTMX
      COMMON /IN74/ ZG,XGDOT,ZGDOT,YGDOT,PPR,QPR,RPR                   0008
      COMMON/DP74/XMU(50,3),XKE(50,3),SI(50,3),SA(50,3),SB(50,3),
     2 SF(50,3),FSPOI(50,3),FSPOF(50,3)                                0033
      COMMON/INTG/ INBUF(50),II(121),KK(121),IR(121),JR(121),          0038
     1            IQ(121),JQ(121),LQ(121),NPQ(121),IKCT                0039
      COMMON/COMALL/ C(6,085),P(50),Q(50),R(50),U(50),V(50),W(50),X(50),0017
     1 Y(50),Z(50),AI(9),AJ(9),XKREF(6,85),SC(50,3),XC(6),
     A XK(3060),XI(50),
     2YI(50),ZI(50),XYI(50),XZI(50),YZI(50),AIJ(9),BIJ(450),DIJ(765),
     3 DRI(085),BAI(450),VEE(510),WGT(50),PHI(50),THETA(50),PSI(50),   0020
     4 PDOT(50),QDOT(50),RDOT(50),UDOT(50),VDOT(50),WDOT(50),XDOT(50), 0021
     5 YDOT(50),ZDOT(50),PHIDOT(50),THEDOT(50),PSIDOT(50),TIME,DELTAT, 0022
     6XACC(50),YACC(50),ZACC(50),AIIAJ(9),AIDOT(9),FMBAR(6,85),
     A DELFMO(3060),
     7 PHIIJ(085),THEIJ(085),PSIIJ(085),SUMDF(6,085),TITLE(20),        0024
     8 XLBAR(50,3),FSPBAR(50,3),VEEDOT(3,3),DX(50),DY(50),DZ(50),      0025
     8 DPIN(50),DQIN(50),DRIN(50),                                     0026
     8             SEIJ(085),DEIJ(085),CEIK(50,3), TMAX                0027
      COMMON / ICOMAL/ MAXNM,MAXIGS,MAXTBL,INDP,                       0025
     A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085), 0029
     B N(510),NN(50,3),ISP(50,3),IJPR(085),IDPLOT(010)                 0030
      COMMON/DERIN1/XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR                0028
      COMMON/DERIN/HEX(50),HEY(50),HEZ(50),ALIFT(50),VMAX(510)         0034
     1 ,PHIDP(50),THEDP(50),PSIDP(50),PHIPR,THEPR,PSIPR                0035
      COMMON/MAINCF/      IPRINT,ITPLOT,IBS(50,3)                      0016
      COMMON/ INT75/ NV                                                0031
      EQUIVALENCE (XK(1),XK3(1,1,1))                                   0032
      COMMON/LINES/XKS(1200),XKR(1200),NLSFLG(510),CHUG(120)
      COMMON/ICSYM/NSYM(20),ISDF(40)
      EQUIVALENCE (VMAX(1),VMAX2(1))                                   0034
      DATA BLANK/'    '/                                               0035
C  ****  READ IN CONTROLS  ****                                        0039
      READ 5200,NM,IPRINT,DELTAT,TMAX,INPAP
      PRINT 5501,NM,IPRINT,DELTAT,TMAX,INPAP
 5501 FORMAT( ' MASSES=' I3 'DP/DT=' I3 'DT=' E12.5 'TMAX=' E12.5
     1 'INPAP=' I3)
C     INPUT MASS #'S IN ASCENDING ORDER WITH LONGITUDINAL SYMMETRY     0042
      READ 6001, (NSYM(JK),JK=1,20)                                    0042
 6002 FORMAT('0LONGITUDINAL SYMMETRY AT MASSES NSYM(JK)=',/2X,         0042
     120(I4,2H, ))
 6001 FORMAT(20I4)
      READ 6001,(ISDF(JK),JK=1,40)
      PRINT 6002, (NSYM(JK),JK=1,20)                                   0042
      PRINT 6003,(ISDF(JK),JK=1,40)
 6003 FORMAT('0BEAMS IN COMPRESSION OR TENSION ISDF(IGS)=',/2X,
     120(I4,2H, ))
C  ****  READ IN INITIAL CONDITIONS ****                               0042
      READ 5300,PNV,EEQ,EER,EROT
      IF(EEQ.EQ.0.)EEQ=.001
      IF(EER.EQ.0.) EER=0.001
      IF(EROT.EQ.0.)EROT=.001
      PRINT 5542,EEQ,EER,EROT
 5542 FORMAT(' INTEGRATION CONTROLS AND ERROR TOLERANCE',' EEQ=',E12.5,
     1' EER=',E12.5,' EROT=',E12.5)
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```
      PRINT 5543
 5543 FORMAT(///2X,'****INITIAL CONDITIONS*****')
      NV=PNV                                                          0042
      PRINT 5540,NV                                                   0042
 5540 FORMAT(2X,'THE FIRST NV MASSES HAVE ZERO INITIAL VELOCITIES',/
     1 5X,'NV=',I4)
      IF(DELTAT) 5017,5017,5018                                       0043
 5017 NM = 0                                                          0044
      GO TO 5000                                                      0045
 5018 CONTINUE                                                        0046
      IF(NM) 5000,5000,5016                                           0047
 5200 FORMAT(2I3,2E12.4,I3)
 5016 READ5300, XGDOT,YGDOT,ZGDOT                                     0049
      READ5300, PPR,QPR,RPR                                           0050
      READ5300, PHIPR,THEPR,PSIPR,ZG                                  0051
 5300 FORMAT(6E12.5)
      PRINT 5502, XGDOT,YGDOT,ZGDOT                                   0053
 5502 FORMAT('  XGDOT =',1PE13.5,'  YGDOT =',E13.5,'  ZGDOT =',E13.5) 0054
      PRINT 5503, PPR,QPR,RPR                                         0055
 5503 FORMAT(5X,'P'' =',1PE13.5,5X,'Q'' =',E13.5,5X,'R'' =',E13.5)    0056
      PRINT 5504, PHIPR,THEPR,PSIPR,ZG                                0057
 5504 FORMAT('   PHI'' =',1PE13.5,' THETA'' =',E13.5,'   PSI'' =',E13.5,0058
     1  5X,'ZG =',E13.5)                                              0059
C  ****  READ IN BULK DATA  ****                                      0059
      PRINT 5541                                                      0059
 5541 FORMAT(///2X,'**** BULK DATA ****',/)                           0059
C READ WEIGHTS                                                        0060
      READ5600, (WGT(I),I=1,NM)                                       0061
      PRINT 5505                                                      0062
 5505 FORMAT('0WEIGHTS')                                              0063
      PRINT 5506, (I,WGT(I),I=1,NM)                                   0064
 5506 FORMAT(1H ,I3,1PE15.5)                                          0065
C READ MOMENTS AND INERTIA PRODUCTS                                   0066
      READ5300, (XI(I),YI(I),ZI(I),XYI(I),YZI(I),XZI(I),I=1,NM)       0067
      READ5700, (XOP(I),YOP(I),ZOP(I),I=1,NM)                         0068
 5700 FORMAT(3E12.0)                                                  0069
      PRINT 5701
 5701 FORMAT(//1X,'INERTIAS')
      PRINT 5507                                                      0070
 5507 FORMAT('0I,IX(I),IY(I),IZ(I),IXY(I),IYZ(I),IXZ(I)')             0071
      PRINT 5508, (I,XI(I),YI(I),ZI(I),XYI(I),YZI(I),XZI(I),I=1,NM)   0072
 5508 FORMAT(1H ,I5,1P6E15.5)                                         0073
      PRINT 5702
 5702 FORMAT(//1X,'COORDINATES')
      PRINT 5509                                                      0074
 5509 FORMAT('0I,X''''(I),Y''''(I),Z''''(I)')                         0075
      PRINT 5510, (I,XOP(I),YOP(I),ZOP(I),I=1,NM)                     0076
 5510 FORMAT(1H ,I3,1P3E15.5)                                         0077
C*****CLEAR SOME ARRAYS WHICH ARE SPARSE                              0078
      DO 5110 I = 1,NM                                                0079
      HEX(I) = 0.0                                                    0080
      HEY(I) = 0.0                                                    0081
      HEZ(I) = 0.0                                                    0082
      PHIDP(I) = 0.0                                                  0083
      THEDP(I) = 0.0                                                  0084
      PSIDP(I) = 0.0                                                  0085
 5110 ALIFT(I) = 0.0                                                  0086
C*****READ POINTERS TO NON-ZERO ANGULAR MOMENTUM CARDS                0087
      READ 5800, NI,(INBUF(I),I=1,NI)                                 0088
      PRINT 5511, NI                                                  0089
 5511 FORMAT('0THERE ARE',I3,' I''S HAVING NON-ZERO HE OR ',          0090
     1 'PHI'''',THETA'''',PSI''''')                                   0091
      IF(NI.EQ.0) GO TO 5533                                          0092
      PRINT 5512                                                      0093
 5512 FORMAT('0I,HEX(I),HEY(I),HEZ(I),PHI''''(I),THETA''''(I),',      0094
     1 ,'PSI''''(I)')                                                 0095
C*****NOW READ NON-ZERO CARDS                                         0096
      DO 5120 I = 1,NI                                                0097
      J = INBUF(I)                                                    0098
      READ 5300, HEX(J),HEY(J),HEZ(J),PHIDP(J),THEDP(J),PSIDP(J)      0099
```

```
 5120 PRINT 5508, J,HEX(J),HEY(J),HEZ(J),PHIDP(J),THEDP(J),PSIDP(J)
C*****READ POINTERS TO NON-ZERO AERODYNAMIC LIFTS
 5533 READ 5800, NI,(INBUF(I),I=1,NI)
 5800 FORMAT(38I2)
      PRINT 5513, NI
 5513 FORMAT('0THERE ARE',I3,' I''S HAVING NON-ZERO LC''S')
      IF(NI.EQ.0) GO TO 5534
C*****READ NON-ZERO LIFTS
      READ 5600, (ALIFT(INBUF(I)),I=1,NI)
 5600 FORMAT(E12.0)
      PRINT 5514
 5514 FORMAT('0I,LC(I)')
      PRINT 5506, (INBUF(I),ALIFT(INBUF(I)),I=1,NI)
C*****CLEAR EXTERNAL SPRING FLAGS (AND THE ASSOCIATED DATA ALTHO THIS
C SHOULD NOT BE NECESSARY BECAUSE WE ONLY USE IT IF THE FLAG IS 1.
C HOWEVER, THEY MUST BE CLEARED FOR THE SEARCH WHICH PRINTS THE INPUT.)
 5534 DO 5130 K = 1,3
      DO 5130 I = 1,NM
      ISP(I,K) = 0
      XLBAR(I,K) = 0.0
      XMU(I,K) = 0.0
      XKE(I,K) = 0.0
      SI(I,K) = 0.0
      SA(I,K) = 0.0
      SB(I,K) = 0.0
      SF(I,K) = 0.0
      FSPOI(I,K) = 0.0
 5130 FSPOF(I,K) = 0.0
C*****READ THE SPRING STUFF AND STORE IT.
      IKCT = 1
      PRINT 7010
 7010 FORMAT(//1X,'SPRING DATA')
      PRINT 5515
 5515 FORMAT('0I,K,LBAR(I,K),MU(I,K),KE(I,K)')
 5140 READ 5810, II(IKCT),KK(IKCT),LBAR,MU,KE
 5810 FORMAT(2I3,6X,3E12.0)
      I = II(IKCT)
      IF(I.EQ.0) GO TO 5150
      K = KK(IKCT)
      ISP(I,K) = 1
      XLBAR(I,K) = LBAR
      XMU(I,K) = MU
      XKE(I,K) = KE
      PRINT 5516, I,K,LBAR,MU,KE
 5516 FORMAT(1H ,2I3,1P3E15.5)
      IKCT = IKCT+1
      GO TO 5140
 5150 IKCT = IKCT-1
      IF(IKCT.EQ.0) GO TO 5535
      PRINT 5517
 5517 FORMAT('0I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K),',
     1 'FSPOF(I,K)')
C*****READ SI,SA,SB,SF,FSPOI,FSPOF
      DO 5160 J = 1,IKCT
      I = II(J)
      K = KK(J)
      READ 5300, SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K),FSPOF(I,K)
 5160 PRINT 5518, I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K),
     1 FSPOF(I,K)
 5518 FORMAT(1H ,2I3,1P6E15.5)
 5535 IGS = 0
      PRINT 5519
 5519 FORMAT('0I,J,PN,PHI(I,J),THETA(I,J),PSI(I,J) (INTERNAL BEAMS)')
C READ THE I,J,PHIIJ,THEIJ,PSIIJ
 6015 READ 5400,I,J,PN1,PHIIN,THEIN,PSIIN
 5400 FORMAT(2I3,4E12.0)
      IF(I) 5051,5051,5020
 5020 IGS = IGS+1
      PN(IGS)=PN1
      IG(IGS) = I
```

```
      JG(IGS) = J
      PHIIJ(IGS) = PHIIN
      THEIJ(IGS) = THEIN
      PSIIJ(IGS) = PSIIN
      PRINT 5539,IGS,I,J,PN1,PHIIN,THEIN,PSIIN
 5539 FORMAT(1H ,3I3,1P6E15.5)
      GO TO 5014
C*****THESE K-MATRICES ARE STORED BY ROW, THUS THE THE L,K
 5051 READ5300,(((XK3(L,K,IJ),L=1,6),K=1,6),IJ=1,IGS)
      PRINT 5520
 5520 FORMAT('0IJ,I,K-MATRIX FOR INTERNAL BEAM IJ')
C     PRINT 1237,IGS,IG(IGS),JG(IGS)
      DO 5521 IJ = 1,IGS
      PRINT 5516, IG(IJ),JG(IJ)
C1237 FORMAT(1H,3I3)
 5521 PRINT 5522, ((XK3(L,K,IJ),L=1,6),K=1,6)
 5522 FORMAT(1H ,1P6E15.5)
      READ5600, (CBAR(IJ),IJ=1,IGS)
C     STORE 'CBARS' IN 'C' ARRAY TO BE USED IN SUBROUTINE DOAIJ
      PRINT 5523
 5523 FORMAT('0IJ,I,J,CBAR(I,J)')
      PRINT 5524, (IJ,IG(IJ),JG(IJ),CBAR(IJ),IJ=1,IGS)
 5524 FORMAT(1H ,3I3,1PE15.5)
C******KR TABLE INPUT
C IN DERIV, TO SEE IF THERE IS A TABLE FOR A PARTICULAR IJL, WE LOOK
C AT NLSFLG(IJL) AND IF IT IS NON-ZERO, IT WILL BE THE TABLE NUMBER
C FOR THAT IJL.  WE STILL USE SLOPES AND INTERCEPTS FOR THE
C INTERPOLATION BUT WE MUST FIND WHICH INTERVAL IN X WE'RE IN.
C THIS IS DONE BY KEEPING, FOR EACH TABLE, A POINTER TO THE LOWER X OF
C THE INTERVAL WE WERE IN AT THE LAST INTEGRATION STEP
C (INTEGER*2 CHUG(30)) ON THE GROUNDS THAT WE'RE PROBABLY
C STILL IN THAT INTERVAL.  IF WE'RE NOT IN THAT INTERVAL, WE CHECK
C ONE BY ONE IN THE APPROPRIATE DIRECTION UNTIL WE FIND THE RIGHT
C INTERVAL AND WE SAVE THAT IN CHUG AND DO THE INTERPOLATION.
C X(1) AND X(NPQ) FOR EACH TABLE ARE REPLACED BY VERY LARGE  E35)
C NEGATIVE AND POSITIVE NUMBERS SO THAT WE NEED NEVER CHECK FOR BEING
C OUT OF THE TABLE AND ALSO SO WE DON'T EVEN HAVE TO KNOW HOW MANY
C POINTS IN THE TABLE.  (IF AN ARGUMENT EXCEEDS 1.E35 WE'LL BOMB
C SOONER OR LATER). THIS ALLOWS VERY RAPID TABLE SEARCH AND
C INTERPOLATION.
C*****CLEAR I,J,L NONLINEAR STIFFNESS FLAGS
      MXIGS6 = 6*MAXIGS
      DO 5010 I = 1,MXIGS6
 5010 NLSFLG(I) = 0
C*****INPUT KR TABLE SPECS
      NQ = 0
C*****DO TO # OF TABLES ALLOWED + 1*****C
      MXTBL1 = MAXTBL+1
      DO 5090 I = 1,MXTBL1
      READ5900, IQ(I),JQ(I),LQ(I),NPQ(I)
 5900 FORMAT(4I3)
      IF(IQ(I).EQ.0) GO TO 5050
      NQ = I
C*****HUNT FOR I,J PAIR SO WE CAN STORE NQ IN NLSFLG
      DO 5030 J = 1,IGS
      IF(IQ(I).EQ.IG(J).AND.JQ(I).EQ.JG(J)) GO TO 5040
 5030 CONTINUE
C*****NO SUCH I,J PAIR, ABORT
      PRINT5910, IQ(I),JQ(I)
      STOP
 5910 FORMAT(1H,'NON-EXISTENT I,J PAIR IN KR TABLE SPECS',2I5)
C*****FOUND IT
 5040 NLSFLG(6*(J-1)+LQ(I)) = NQ
 5090 CONTINUE
C*****TOO MANY KR TABLES, ABORT
      PRINT5920
      STOP
 5920 FORMAT(1H,'TOO MANY KR TABLES')
C*****PRINT KR TABLE SPECS
 5050 IF(NQ.EQ.0) GO TO 5536
```

```
      PRINT 5930
 5930 FORMAT('0KR TABLE SPECS, I,J,L,NP')
      PRINT5940,(IQ(I),JQ(I),LQ(I),NPQ(I),I=1,NQ)
 5940 FORMAT(1H ,4I5)
C*****LOOP TO READ IN A TABLE
      K=-9
      DO 5070 I = 1,NQ
      NP = NPQ(I)
      IF(NP.LE.10) GO TO 5055
C*****TOO MANY POINTS IN KR TABLE, ABORT
      PRINT 5980, NP,I
      STOP
 5980 FORMAT(1H ,I5,' POINTS IN KR TABLE ',I3, ' (MAX IS 10)')
C*****SET CHUG TO 1,11,21,.....
 5055 K=K+10
      CHUG(I) = K
      ICH = CHUG(I)-1
      READ5950, (XKR(ICH+J),KR(J),J=1,NP)
 5950 FORMAT(2E12.0)
C*****PRINT TABLE
      PRINT5960,IQ(I),JQ(I),LQ(I),ICH
 5960 FORMAT(1H0,'KR TABLE FOR I,J,L =',3I5,4X'TABLE ICH=',I4)
      PRINT5970, (J,XKR(ICH+J),KR(J),J=1,NP)
 5970 FORMAT(1H ,I3,1P2E15.5)
C*****COMPUTE SLOPES AND INTERCEPTS
      NPM1 = NP-1
      DO 5080 J = 1,NPM1
      SLOPE=KR(J)
      XKS(ICH+J) = SLOPE
 5080 CONTINUE
C*****MOVE ENDPOINTS WAY OUT
C     XKR(ICH+1)=-1.E35
C     XKR(ICH+NP)=1.E35
 5070 CONTINUE
C*****STANDARD VMAX = 100
 5536 DO 5180 I = 1,MXIGS6
 5180 VMAX(I) = 100.0
      PRINT 5525
 5525 FORMAT('0I,J,VMAX(1,J,-6)')
      IJCT = 0
 5170 IJCT = IJCT+1
      READ 5820, IR(IJCT),JR(IJCT)
 5820 FORMAT(2I3)
      IF(IR(IJCT).NE.0) GO TO 5170
      IJCT = IJCT-1
C*****READ NON-STANDARD MAXIMUM DEFLECTIONS
      IF(IJCT.EQ.0) GO TO 5537
      DO 5190 K = 1,IJCT
      I = IR(K)
      J = JR(K)
C*****HUNT FOR I,J PAIR (MUST HUNT)
      DO 5210 L = 1,IGS
      IF(I.EQ.IG(L).AND.J.EQ.JG(L)) GO TO 5220
 5210 CONTINUE
C*****NO SUCH PAIR, ABORT
      PRINT 5830, K,I,J
      STOP
 5830 FORMAT(1H ,I3,'TH I,J PAIR(',2I3,') FOR VMAX DOES NOT EXIST.')
C*****FOUND IT, READ A VMAX CARD
 5220 READ 5300, (VMAX2(M,L),M=1,6)
      PRINT 5539, (L,I,J,(VMAX2(M,L),M=1,6))
 5190 CONTINUE
C      NOPLOT    = # OF PLOTS , MAX VALUE IS 5
C      PLTT      = TIME FOR FIRST PLOT
C      NPTC      = PRINT CYCLES PER PLOT CYCLE
C      KTYPE(L)  = SPECIFIES PLANE, 1=XY, 2=YZ, 3=XZ    MAX VALUE OF L=5
C      ISCALE(L) = SPECIFIES SCALE, 0 FOR EQUAL SCALE, 1 FOR SCALE ON
C                  VARIABLE
C      NMPT(L,I) = MASSES LISTED TO BE PUT ON EACH PLOT
C                  THE DIMENSION L (MAX=5) REFERS TO THE PLOT #
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C                          DIMENSION I (MAX=40) IS MASS INDICATOR WITH MASSES
C                          LISTED IN ANY ORDER
 5537 IF(NOPLOT.LT.1) GO TO 6000
      IF(NOPLOT.LE.5) GO TO 7020
      PRINT 8002,NOPLOT
      STOP
 7020 READ 8000, PLTT,PNPTC
      NPTC= PNPTC
      PRINT 8001,NOPLOT,PLTT,NPTC
      DO 7030 L=1,NOPLOT
        READ 8003, (SUBI(L,J),J=1,20)
        READ 8004, KTYPE(L),ISCALE(L)
        READ 8004, (NMPT(L,I),I=1,40)
 7030 CONTINUE
      PRINT 8005, (KTYPE(L),L=1,NOPLOT)
 8000 FORMAT(6E12.6)
 8001 FORMAT( ' NUMBER OF PLOTS NOPLOT=',I4/' TIME FOR FIRST PLOT =',
     X  E12.6/ ' NUMBER PRINT CYCLES / PLOT CYCLE =',I4)
 8002  FORMAT( ' JOB TERMINATED - NUMBER OF PLOTS REQUESTED GREATER  THA
     XN 5 NOPLOT=',I4)
 8003 FORMAT(20A4)
 8004 FORMAT(40I2)
 8005 FORMAT( ' THE PLOT  TYPES SELECTED ARE KTYPE=  ',5(I4))
 6000 READ 5800,INDP
      PRINT 5538, INDP
 5538 FORMAT('0INDP =',I3)
      IF (INDP.EQ.0)  GO TO 5065
      READ5300, XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR
      PRINT 5530
 5530 FORMAT('0XN-,XP-,YN-,YP-,ZN-,ZP-',/)
      PRINT 5529, XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR
 5065 READ 5928, IJPR
      PRINT 5531
 5531 FORMAT(1H0,34X,'DRI(IJ) INDICATORS',/)
      PRINT 5526
      PRINT 5527
      PRINT 5532, IJPR
      IF(NOPLOT.LE.0) GO TO 5000
 5532 FORMAT(4X,80A1)
C IF WE KNOW HOW MANY PLOTS WE WANT, WE CAN FIGURE OUT HOW MANY POINTS
C PER PLOT WE CAN HAVE, ALTHO WE DON'T WANT MORE THAN 500, BECAUSE
C WE COULDN'T NOTICE THE RESOLUTION ANYWAY.THE REST OF THIS FIGURES
C OUT HOW OFTEN TO SAVE. A TRUNCATED ITPLOT WILL TRY TO SAVE TOO MUCH
C AND THEN WE WOULDN'T GET TO TMAX, BUT IF WE WOULD ALMOST GET THERE
C IT WILL NOT BE NOTICEABLE ON THE PLOT.
      IF (NPLOT.EQ.0)  GO TO 5060
      IP = 30000/NPLOT
      IF(IP.GT.500) IP = 500
      FITER = TMAX/DELTAT+2.0
      ITPLOT = FITER/IP
      IF(ITPLOT.EQ.0) ITPLOT = 1
      IF(FITER/(IP*ITPLOT).GT.1.002) ITPLOT = ITPLOT+1
 5060 CONTINUE
 5000 RETURN
 5526 FORMAT(13X,'1',9X,'2',9X,'3',9X,'4',9X,'5',9X,'6',9X,'7',9X,'8')
 5527 FORMAT(4X,'12345678901234567890123456789012345678901234567890',
     X'123456789012345678901234567890',/)
 5928 FORMAT(80A1)
      END
!ASS (M:SO,LO)
!ASS (M:CI,D5,S79RST:F)


!CUP CI,SO
      SUBROUTINE PRINT
      IMPLICIT REAL*8(A-H,O-Z)
C       MEMBER NAME S79RPRT
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      INTEGER*4 BLANK,ASTRIC,XBLANK,
     1 YIELD,PLAST,YIE,PLA,RUPT
      REAL*4 KEI(50),PEI(50)
      DIMENSION VEE2(6,85)
      DIMENSION YIE(85),PLA(85),RUPT(85)
      COMMON/PLOT1/ NOPLOT,NMPT(5,40),ISCALE(5),KTYPE(5),NPTC,KPLT
      COMMON/STITLE/ SUBI(5,20),PLTT
      DIMENSION VV(40),WW(40)
      COMMON/VARSTP/ DELTMN,DELSV,EER,EEQ,EROT,ERROR
     1,TMX,TTMX,TTTMX
      COMMON/INT75/ NV                                                  0005
      COMMON/ COMPLY/PROP(20,3),PTIM,TMEL(085),CKPT(085,4,8),EALW(085,4)0039
      COMMON/ ICOPLY/ NE(085),NOS,NID(085),NCP(085),NS,L3               0039
      COMMON/ PYLD/SIGB(085,4),TXY(085,4),TXZ(085,4),SU(085,4),SV(085,4)0039
      COMMON/IPYLD/YIELD(085,4),PLAST(085,4)
      COMMON/IDERV/IRUPSW(085),IPENSW(085)                              0005
C                                                                       0006
      COMMON/INTG/ INBUF(50),II(121),KK(121),IR(121),JR(121),           0038
     1             IQ(121),JQ(121),LQ(121),NPQ(121),IKCT                0008
      COMMON/COMALL/ C(6,085),P(50),Q(50),R(50),U(50),V(50),W(50),X(50),0017
     1 Y(50),Z(50),AI(9),AJ(9),XKREF(6,85),SC(50,3),XC(6),
     A XK(3060),XI(50),
     2YI(50),ZI(50),XYI(50),XZI(50),YZI(50),AIJ(9),BIJ(450),DIJ(765),
     3 DRI(085),OAI(450),VEE(510),WGT(50),PHI(50),THETA(50),PSI(50),    0020
     4 PDOT(50),QDOT(50),RDOT(50),UDOT(50),VDOT(50),WDOT(50),XDOT(50),  0021
     5 YDOT(50),ZDOT(50),PHIDOT(50),THEDOT(50),PSIDOT(50),TIME,DELTAT,  0022
     6XACC(50),YACC(50),ZACC(50),AITAJ(9),AIDOT(9),FMBAR(6,85),
     A DELFMO(3060),
     7 PHIIJ(085),THEIJ(085),PSIIJ(085),SUMDF(6,085),TITLE(20),         0024
     8 XLBAR(50,3),FSPBAR(50,3),VEEDOT(3,3),DX(50),DY(50),DZ(50),       0025
     8 DPIN(50),DQIN(50),DRIN(50),                                      0026
     8             SEIJ(085),DEIJ(085),CEIK(50,3), TMAX                 0027
      COMMON / ICOMAL/ MAXNM,MAXIGS,MAXTBL,INDP,                        0020
     A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085), 0029
     B N(510),NN(50,3),ISP(50,3),IJPR(085),IDPLOT(010)                  0030
      EQUIVALENCE (VEE(1),VEE2(1))                                      0023
      DATA ASTRIC,BLANK,XBLANK/4H   *,4H    ,4H    /
      ILINES = 60                                                       0025
      IPL = 6                                                           0026
      ITTL = 9                                                          0027
C FORCE NEW PAGE                                                        0028
      NPR = 1000                                                        0029
      DO 3099 I = 1,NM                                                  0030
      IF (ILINES-NPR-IPL) 3010,3020,3020                                0031
 3010 PRINT 3100,TITLE,TIME                                             0032
 3100 FORMAT(1H1,20A4,//1H ,6HTIME =,F12.8,//1H ,18X,1HX,14X,1HY,14X,1HZ,
     113X,3HPHI,11X,5HTHETA,11X,3HPSI,/1H ,17X,4HXDOT,11X,4HYDOT,11X,   0034
     24HZDOT,10X,6HPHIDOT,8X,8HTHETADOT,8X,6HPSIDOT,/1H ,18X,1HU,14X,   0035
     31HV,14X,1HW,14X,1HP,14X,1HQ,14X,1HR,/1H ,17X,4HUDOT,11X,4HVDOT,   0036
     411X,4HWDOT,11X,4HPDOT,11X,4HQDOT,11X,4HRDOT,/1H ,16X,6HXACCEL,9X, 0037
     56HYACCEL,9X,6HZACCEL,/)                                           0038
      IF(ERROR.GT.0.) PRINT 3101,ERROR
 3101 FORMAT(/' NUMBER OF INT USING DELTMN=',F10.4)
      ERROR=0.
      NPR = ITTL                                                        0049
 3020 NPR = NPR+IPL                                                     0050
      PRINT 700,I,X(I),Y(I),Z(I),PHI(I),THETA(I),PSI(I),                0051
     1XDOT(I),YDOT(I),ZDOT(I),PHIDOT(I),THEDOT(I),PSIDOT(I),            0052
     2U(I),V(I),W(I),P(I),Q(I),R(I),                                    0053
     3UDOT(I),VDOT(I),WDOT(I),PDOT(I),QDOT(I),RDOT(I),                  0054
     4XACC(I),YACC(I),ZACC(I)                                           0055
  700 FORMAT(/1H ,5HMASS ,I2,2X,1P6E15.5,/4(1H ,9X,1P6E15.5,/))         0056
 3099 CONTINUE                                                          0059
      PRINT 830                                                         0060
C     DO LOOPS 910&920 DETERMINE PLASTIC&RUPTURE INDICATORS FOR BEAMS   0061
      DO 910 K=1,IGS                                                    0061
      YIE(K)=XBLANK
      PLA(K)=XBLANK
      RUPT(K)=XBLANK
      DO 920 MM=1,4
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      IF(YIELD(K,MM).EQ.ASTRIC) YIE(K)=ASTRIC
      YIELD(K,MM)=BLANK
      IF(PLAST(K,MM).EQ.ASTRIC) PLA(K)=ASTRIC
  920 CONTINUE
  910 IF(IRUPSW(K).NE.0) RUPT(K)=ASTRIC                                 0061
  830 FORMAT(//1H ,'IG(IJ),JG(IJ),SUMDF(1,IJ),SUMDF(2,IJ),',4X,         0062
     1'SUMDF(3,IJ),',3X,'SUMDF(4,IJ),',3X,'SUMDF(5,IJ),',3X,            0063
     2'SUMDF(6,IJ),',2X,'YIELD',2X,'PLAST')                              0063
  840 PRINT 810,(IG(IJ),JG(IJ),(SUMDF(K,IJ),K=1,6),YIE(IJ),PLA(IJ),     0064
     1IJ=1,IGS)                                                          0064
      PRINT 831                                                          0065
  831 FORMAT(/1H ,'IG(IJ),JG(IJ),VEE2(1,IJ),VEE2(2,IJ),',6X,            0066
     1'VEE2(3,IJ),',5X,'VEE2(4,IJ),',5X,'VEE2(5,IJ),',5X,               0067
     2'VEE2(6,IJ),',3X,'RUPTURE')                                        0067
      M=6*IGS                                                            0067
      PRINT 811,(IG(IJ),JG(IJ),(VEE2(K,IJ),K=1,6),RUPT(IJ),IJ=1,IGS)    0068
  810 FORMAT(1H ,1X,I2,2X,I2,2X,1P6E15.5,2X,A4,2X,A4)                   0069
  811 FORMAT(1H ,1X,I2,2X,I2,2X,1P6E15.5,2X,A4)                         0069
      PRINT 833,TITLE
  833 FORMAT(1H1,20A4)
      PRINT 4000,TIME
 4000 FORMAT( ' TIME=' F12.8)
      PRINT 832                                                          0070
  832 FORMAT(/1H ,'I,SC(I,1),SC(I,2),SC(I,3)' )
      DO 3040 I = 1,NM                                                   0072
      DO 3050 J = 1,3                                                    0073
      IF(ISP(I,J).NE.0) GO TO 3060                                       0074
 3050 CONTINUE                                                           0075
      GO TO 3040                                                         0076
 3060 PRINT 820, I,(SC(I,J),J=1,3)                                       0077
  820 FORMAT(1H ,I7,2X,1P3E15.5)                                         0078
 3040 CONTINUE                                                           0079
      ISET=0                                                             0080
      DO 3070 I = 1,IGS                                                  0081
      IF(IJPR(I).EQ.BLANK) GO TO 3070                                    0082
      IF (ISET.EQ.1)  GO TO 3065                                         0083
      PRINT 821                                                          0084
  821 FORMAT(1H //1X,'MASS',7X,'DRI')                                    0085
      ISET=1                                                             0086
 3065 PRINT 822, JG(I),DRI(I)                                            0087
 3070 CONTINUE                                                           0088
  822 FORMAT(1H ,1X,I2,3X,1PE15.5)                                       0089
      SUMMVX=0.                                                          0089
      SUMMVY=0.                                                          0089
      SUMMVZ=0.                                                          0089
      SUMWGT=0.                                                          0089
      SUMKEI=0.0                                                         0090
      SUMPEI=0.0                                                         0091
      SUMSEI=0.0                                                         0092
      SUMDEI=0.0                                                         0093
      SUMCEI=0.0                                                         0094
      DO 3400 I=1,NM                                                     0095
C****** DON'T USE AN I IF IT'S = TO A J OF A DRI(IJ) PAIR               0096
      DO 3408 IJ=1,IGS                                                   0097
      IF(IJPR(IJ).EQ.BLANK)GO TO 3408                                    0098
      IF(I.NE.JG(IJ))GO TO 3408                                          0099
      PEI(I)=0.0                                                         0100
      KEI(I)=0.0                                                         0101
      GO TO 3999                                                         0102
 3408 CONTINUE                                                           0103
      PEI(I)=-WGT(I)* Z(I)                                               0104
      SUMPEI=SUMPEI+PEI(I)                                               0105
      KEI(I)=.5*(WGT(I)*(U(I)*U(I)+V(I)*V(I)+W(I)*W(I))/386.0            0106
     1 +P(I)*(P(I)*XI(I)+Q(I)*XYI(I)+R(I)*XZI(I))                        0107
     2 +Q(I)*(P(I)*XYI(I)+Q(I)*YI(I)+R(I)*YZI(I))                        0108
     3 +R(I)*(P(I)*XZI(I)+Q(I)*YZI(I)+R(I)*ZI(I)))                       0109
      SUMKEI=SUMKEI+KEI(I)                                               0110
C     THIS TEST IS TO BYPASS MOMENTUM SUMMATION FOR STATIONARY MASSES   0110
 3999 IF(I.LE.NV) GO TO 3400                                             0110
      SUMMVX=SUMMVX+WGT(I)*XDOT(I)/386.                                  0110
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      SUMMVY=SUMMVY+WGT(I)*YDOT(I)/386.
      SUMMVZ=SUMMVZ+WGT(I)*ZDOT(I)/386.
      SUMWGT=SUMWGT+WGT(I)/386.
 3400 CONTINUE
      XDOTCG=SUMMVX/SUMWGT
      YDOTCG=SUMMVY/SUMWGT
      ZDOTCG=SUMMVZ/SUMWGT
      PRINT 3997,SUMMVX,XDOTCG,SUMMVY,YDOTCG,SUMMVZ,ZDOTCG
 3997 FORMAT(/,2X,'***** LINEAR MOMENTUM OF MOVING MASS AGGREGATE*****',
     *//
     11H ,15X,6HSUMMVX,9X,6HXDOTCG,9X,6HSUMMVY,10X,6HYDOTCG,10X,
     26HSUMMVZ,8X,6HZDOTCG,/1H ,9X,1P6E15.5)
      DO 3406 IJ=1,IGS
      SUMSEI=SUMSEI+SEIJ(IJ)
 3406 SUMDEI=SUMDEI+DEIJ(IJ)
      IF(IKCT.EQ.0)GO TO 3409
      DO 3407 IK=1,IKCT
 3407 SUMCEI=SUMCEI+CEIK(II(IK),KK(IK))
 3409 ETOT=SUMKEI+SUMPEI+SUMSEI+SUMDEI+SUMCEI
      PCKE=SUMKEI/ETOT
      PCPE=SUMPEI/ETOT
      PCSE= SUMSEI/ETOT
      PCDE=SUMDEI/ETOT
      PCCE=SUMCEI/ETOT
      PRINT 3401,ETOT,SUMKEI,SUMPEI,SUMSEI,SUMDEI,SUMCEI,
     1PCKE,PCPE,PCSE,PCDE,PCCE
 3401 FORMAT(///,2X,'***** ENERGY CALCULATIONS *****',///1H ,6X,
     1'TOTAL',7X,'KINETIC',6X,'POTENTIAL',7X,'STRAIN',7X,'DAMPING',7X,
     2'CRUSHING',/6X,'ENERGY',5(8X,'ENERGY')//1X,1P6E14.5,//
     3'0   PERCENT OF',2P5F14.3/3X,'TOTAL ENERGY')
      PRINT 3404
 3404 FORMAT('0',50X,'INTERNAL',46X,'EXTERNAL'/53X,'BEAM',49X,'SPRING'/
     17X,'KENETIC',15X,'POTENTIAL',26X,'STRAIN',17X,'DAMPING',20X,
     2 'CRUSHING'/' MASS  ENERGY      PER CENT     ENERGY      PER CENT   I
     3J   I   J     ENERGY     PER CENT        ENERGY     PER CENT    1 K      ENER
     4GY      PER CENT'/)
      MAXEN=MAX0(NM,IGS,IKCT)
      IF(TIME.EQ.0.0)MAXEN=NM
      DO 3410 IO=1,MAXEN
      IOPTR=0
      IF(IO.GT.NM)GO TO 3411
      IOPTR= IOPTR+4
      PCKE=KEI(IO)/SUMKEI
      PCPE=PEI(IO)/SUMPEI
      IF(TIME.EQ.0.0)GO TO 3504
 3411 IF(IO.GT.IGS)GO TO 3412
      IOPTR=IOPTR+2
      IF(SUMSEI.NE.0.0) GO TO 5
      PCSE = 0.0
      GO TO 6
    5 PCSE = SEIJ(IO)/SUMSEI
    6 IF(SUMDEI.NE.0.0) GO TO 7
      PCDE = 0.0
      GO TO 3412
    7 PCDE = DEIJ(IO)/SUMDEI
 3412 IF(IO.GT.IKCT)GO TO 3413
      IOPTR= IOPTR +1
      I= II(IO)
      K=KK(IO)
      CE= CEIK(I,K)
      IF(SUMCEI.NE.0.0) GO TO 9
      PCCE = 0.0
      GO TO 3413
    9 PCCE = CE/SUMCEI
 3413 GO TO(3501,3502,3503,3504,3505,3506,3507),IOPTR
C******* ONLY CE
 3501 PRINT 3511,I,K,CE,PCCE
 3511 FORMAT(104X,I3,I2,1PE13.5,2PF9.3)
      GO TO 3410
C******** SE AND DE
```

```
 3502 PRINT 3512,IO,IG(IO),JG(IO),SEIJ(IO),PCSE,DEIJ(IO),PCDE
 3512 FORMAT(51X,3I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3)
      GO TO 3410
C******** SE, DE, CE
 3503 PRINT 3513,IO,IG(IO),JG(IO),SEIJ(IO),PCSE,DEIJ(IO),PCDE,I,K,CE,
     1 PCCE
 3513 FORMAT(51X,3I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,I4,I2,1PE13.5,2PF9.3)
      GO TO 3410
C******* KE AND PE
 3504 PRINT 3514,IO,KEI(IO),PCKE,PEI(IO),PCPE
 3514 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3)
      GO TO 3410
C***** KE,PE,CE
 3505 PRINT 3515,IO,KEI(IO),PCKE,PEI(IO),PCPE,I,K,CE,PCCE
 3515 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,58X,2I2,1PE13.5,2PF9.3)
      GO TO 3410
C******* KE,PE,SE,DE
 3506 PRINT 3516,IO,KEI(IO),PCKE,PEI(IO),PCPE,IO,IG(IO),JG(IO),SEIJ(IO),
     1 PCSE,DEIJ(IO),PCDE
 3516 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,2X,3I3,1PE13.5,2PF9.3,
     1 1PE14.5,2PF9.3)
      GO TO 3410
C******* KE,PE,SE,DE,CE
 3507 PRINT 3517,IO,KEI(IO),PCKE,PEI(IO),PCPE,IO,IG(IO),JG(IO),SEIJ(IO),
     1PCSE,DEIJ(IO),PCDE,I,K,CE,PCCE
 3517 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,2X,3I3,1PE13.5,2PF9.3,
     1 1PE14.5,2PF9.3,I4,I2,1PE13.5,2PF9.3)
 3410 CONTINUE
      IF(TIME.LE.PTIM.OR.PTIM.LT.0.) GO TO 3650
      IF(NS.LE.0) GO TO 3650
      PRINT 3620
      DO 3600 K=1,NS
      IF(TIME.LE.TMEL(K)) GO TO 3600
      M=NE(K)
      MM=NCP(K)
      PRINT 3630,M
      PRINT 3640, (L,SIGB(K,L),TXY(K,L),TXZ(K,L),SU(K,L),SV(K,L),
     1 YIELD(K,L),PLAST(K,L),L=1,MM)
 3600 CONTINUE
 3620 FORMAT(///,2X,'***** PLASTIC-YIELD OUTPUT *****'//2X,'IGS'/5X,
     A'#CRS',
     14X,'SIGMAX',9X,'TAUXY',11X,'TAUXZ',12X,'SU',13X,'SV',6X,'YIELD',
     11X,'PLAST')
 3630 FORMAT(2X,I3)
 3640 FORMAT(5X,I3,5E15.5,A4,2X,A4)
 3650 IF(NOPLOT.LE.0) RETURN
      IF(TIME.LT.PLTT) KPLT=0
      IF(TIME.LT.PLTT) RETURN
      KPLT=KPLT+1
      IF(KPLT.NE.NPTC.AND.TIME.NE.0.0) RETURN
      KPLT=0
      DO 3651 L=1,NOPLOT
        ISC= ISCALE(L)
        KTY= KTYPE(L)
        DO 3656 K=1,40
          VV(K)=0.
          WW(K)=0.
 3656   CONTINUE
        IF(KTY.EQ.1) GO TO 3652
        IF(KTY.EQ.2) GO TO 3653
        IF(KTY.EQ.3) GO TO 3654
        PRINT 3700,L,KTY
        STOP
 3652   DO 3657 JJ=1,40
          NPT= NMPT(L,JJ)
          IF(NPT.EQ.0) GO TO 3655
          VV(JJ)= X(NPT)
          WW(JJ)= Y(NPT)
          IF(JJ.EQ.40) GO TO 3670
 3657   CONTINUE
```

```
      PRINT 3702,JJ
      STOP
3653  DO 3658 JJ=1,40
        NPT= NMPT(L,JJ)
        IF(NPT.EQ.0) GO TO 3655
        VV(JJ)= Y(NPT)
     WW(JJ)=-Z(NPT)
        IF(JJ.EQ.40) GO TO 3670
3658  CONTINUE
      PRINT 3702,JJ
      STOP
3654  DO 3659 JJ=1,40
        NPT=NMPT(L,JJ)
        IF(NPT.EQ.0) GO TO 3655
        VV(JJ)= X(NPT)
     WW(JJ)=-Z(NPT)
        IF(JJ.EQ.40) GO TO 3670
3659  CONTINUE
      PRINT 3702,JJ
      STOP
3655  JJ= JJ-1
3670  CONTINUE
     PRINT 3701, (SUBI(L,K),K=1,20),TIME
      PRINT 3680, (NMPT(L,K),K=1,JJ)
3680 FORMAT( '  MASS NUMBERS PLOTTED'/ 2(5X,20I4))
      CALL PAPLOT(VV,WW,JJ,ISC)
3651 CONTINUE
     RETURN
3700 FORMAT( ' INVALID PLOT TYPE INPUTTED L= ',I4,' KTYPE(L)=',I4)
3701 FORMAT( 1H1,20A4/ ' TIME= ',E15.6)
3702 FORMAT( ' JOB TERMINATED IN PRINT ROUTINE'/
    X ' PLOT SELECTION INDICE IN ONE OF 3650 LOOPS OUT OF RANGE JJ=',
    Y I4)
     END                                                          0200

!CUP CI,S0
      SUBROUTINE EULER(A,PHI,THETA,PSI)                           0001
      IMPLICIT REAL*8(A-H,O-Z)
C     MEMBERNAME S79REU
       DIMENSION A(9)
      SIN(G)= DSIN(G)                                             0005
      COS(G)= DCOS(G)                                             0006
      C1 = COS(PHI)                                               0008
      S2 = SIN(THETA)                                             0009
      C2 = COS(THETA)                                             0010
      S3 = SIN(PSI)                                               0011
      C3 = COS(PSI)                                               0012
      A(1) =  C2*C3                                               0013
      A(2) =  C2*S3                                               0014
      A(3) = -S2                                                  0015
      A(4) = -C1*S3+S1*S2*C3                                      0016
      A(5) =  C1*C3+S1*S2*S3                                      0017
      A(6) =  S1*C2                                               0018
      A(7) =  S1*S3+C1*S2*C3                                      0019
      A(8) = -S1*C3+C1*S2*S3                                      0020
      A(9) =  C1*C2                                               0021
      RETURN                                                      0022
      END                                                         0023
!ASS (M:S0,L0)
!ASS (M:CI,D5,S79RIN:F)
```

```
!CUP CI,S0
      SUBROUTINE PLASTN                                                 0001
      IMPLICIT REAL*8(A-H,O-Z)
C     MEMBER NAME S79RPLIN                                              0002
C     THIS ROUTINE READS IN DATA FOR PLASTIC-YIELD CRITERIA             0003
C    DATA IS READ IN FROM UNIT L3 DEFINED BY 1ST READ IN THIS ROUTINE   0004
C                                                                       0005
      COMMON/ CCMPLY/PROP(20,3),PTIM,THEL(085),CKPT(085,4,8),EALW(085,4)0039
C                                                                       0007
      COMMON/ ICOPLY/ NE(085),NDS,NID(085),NCP(085),NS,L3               0039
C                                                                       0009
      COMMON/ ICOMAL/ MAXNM,MAXIGS,MAXTBL,INDP,                         0010
     A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085), 0029
     B N(510),NN(50,3),ISP(50,3),IJPR(085),IDPLOT(010)                  0030
      DIMENSION EID(85),CP(85)
      READ 100,XL3
      IF(XL3.LE.0.0) RETURN
      L3=XL3                                                            0013
C    *** CONTROLS FOR PLASTIC-YIELD CRITERIA ***                        0013
      READ(L3,100) PTIM,DS,ELSS                                         0014
      NS=ELSS                                                           0015
      NDS=DS                                                            0016
      PRINT 101,PTIM,NDS,NS                                             0017
      IF(PTIM.LT.0.) GO TO 420                                          0018
      DO 400 K=1,85
  400 NE(K)=0                                                           0020
      READ(L3,100) ((PROP(K,M),M=1,3),K=1,NDS)                          0021
      PRINT 112                                                         0022
      PRINT 102,(K,(PROP(K,M),M=1,3),K=1,NDS)                           0023
      READ(L3,103)  (NE(K),EID(K),CP(K),THEL(K),K=1,NS)                 0024
      PRINT 113                                                         0025
      PRINT 104, (K,NE(K),EID(K),CP(K),THEL(K),K=1,NS)                  0026
      DO 410 K=1,NS                                                     0027
      NID(K)=EID(K)                                                     0028
  410 NCP(K)=CP(K)                                                      0029
      READ(L3,110) ((EALW(K,M),M=1,4),K=1,NS)                           0030
      PRINT 114                                                         0031
      PRINT 107,(K,NE(K),(EALW(K,M),M=1,4),K=1,NS)                      0032
      PRINT 115                                                         0033
      DO 430 K=1,NS                                                     0034
      MM=NCP(K)                                                         0035
      READ(L3,106) ((CKPT(K,M,L),L=1,8),M=1,MM)                         0036
      PRINT 108,K,NE(K)                                                 0037
  430 PRINT 111, ((CKPT(K,M,L),L=1,8),M=1,MM)                           0038
  420 PRINT 109                                                         0039
  100 FORMAT(6E12.5)                                                    0040
  101 FORMAT(///2X,'PLASTIC-YIELD CRITERIA DATA',/2X,'START TIME=',     0041
     1 E12.4,2X,'NO. OF PROPERTY SETS=',I4,'NO. OF ELTS=',I4)           0042
  102 FORMAT(2X,I4,1P3E12.4)                                            0043
  103 FORMAT(I5,3E12.4)                                                 0044
  104 FORMAT(2X,2I4,1P3E12.4)                                           0045
  106 FORMAT(6E12.4,/2E12.4)                                            0046
  107 FORMAT(2X,2I4,1P4E12.4)                                           0047
  108 FORMAT(2X,2I4)                                                    0048
  109 FORMAT(2X,'*****END OF PLASTIC-YIELD CRITERIA INPUT *****')       0049
  110 FORMAT(4E12.4)                                                    0050
  111 FORMAT(10X,8E12.4)                                                0051
  112 FORMAT(1X,'PROP',4X,'AREA',9X,'IYY',9X,'IZZ'/1X,'SET #')          0052
  113 FORMAT(2X,'ID',2X,'IGS',2X,'PROP SET #',3X,'# CKPTS',5X,          0053
     1'TIME FOR CHECK')                                                 0054
  114 FORMAT(2X,'ID',2X,'IGS',15X,'ALLOWABLES FOR CKPTS'/16X,'1',       0055
     111X,'2',12X,'3',11X,'4')                                          0056
  115 FORMAT(2X,'ID',2X,'IGS'/15X,'CY',10X,'CZ',9X,'QYY',9X,'QYZ'       0057
     19X,'QZY',9X,'QZZ',10X,'KY',10X,'KZ')                              0058
      RETURN                                                            0059
      END                                                               0060
!ASS (M:S0,L0)
!ASS (M:CI,D5,S79RCF:F)
```

```
ICUP CI,SO
      SUBROUTINE CFORCE                                                        0001
      IMPLICIT REAL*8(A-H,O-Z)
C       MEMBER NAME S79RCFOR                                                   0002
      COMMON/DP74/XMU(50,3),XKE(50,3),SI(50,3),SA(50,3),SB(50,3),
     2 SF(50,3),FSPOI(50,3),FSPOF(50,3)                                        0033
      DIMENSION VA(3),VADOT(3),PBAR(3),XLNGTH(3),IISP(3),XXLBAR(3),            0006
     1 FSP(3,3),XVOC(3,3),C4(3),C5(3),VC3(3),S(3),SDOT(3),PL(3,3)              0007
      DIMENSION DPORIN(4),DXYZ(3),DXYZPR(3),TERM(6)                            0008
      COMMON/COMALL/ C(6,085),P(50),Q(50),R(50),U(50),V(50),W(50),X(50),       0017
     1 Y(50),Z(50),AI(9),AJ(9),XKREF(6,85),SC(50,3),XC(6),
     A XK(3060),XI(50),
     2YI(50),ZI(50),XYI(50),XZI(50),YZI(50),AIJ(9),BIJ(450),DIJ(765),
     3 ORI(085),OAI(450),VEL(510),WGT(50),PHI(50),THETA(50),PSI(50),           0020
     4 PDOT(50),QDOT(50),RDOT(50),UDOT(50),VDOT(50),WDOT(50),XDOT(50),         0021
     5 YDOT(50),ZDOT(50),PHIDOT(50),THEDOT(50),PSIDOT(50),TIME,DELTAT,         0022
     6XACC(50),YACC(50),ZACC(50),AITAJ(9),AIDOT(9),FMBAR(6,85),
     A DELFMO(3060),
     7 PHIIJ(085),THEIJ(085),PSIIJ(085),SUMDF(6,085),TITLE(20),                0024
     8 XLBAR(50,3),FSPBAR(50,3),VEEDOT(3,3),DX(50),DY(50),DZ(50),              0025
     8 DPIN(50),DQIN(50),DRIN(50),                                             0026
     8                 SEIJ(085),DEIJ(085),CEIK(50,3), TMAX                    0027
      COMMON / ICCMAL/ MAXNM,MAXIGS,MAXTBL,INDP,                               0020
     A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085),        0029
     B N(510),NN(50,3),ISP(50,3),IJPR(085),IDPLOT(010)                         0030
      COMMON/MAINCF/      IPRINT,ITPLOT,IBS(50,3)                              0016
      EQUIVALENCE (C4(1),DXYZ(1)),(C5(1),DXYZPR(1))                            0024
      SQRT(G)= DSQRT(G)                                                        0027
      VA(1) = X(I)                                                             0025
      VA(2) = Y(I)                                                             0026
      VA(3) = Z(I)                                                             0027
      VADOT(1) = XDOT(I)                                                       0028
      VADOT(2) = YDOT(I)                                                       0029
      VADOT(3) = ZDOT(I)                                                       0030
      PBAR(1) = P(I)                                                           0031
      PBAR(2) = Q(I)                                                           0032
      PBAR(3) = R(I)                                                           0033
C INITIALIZE SOME MORE                                                         0034
      DO 910 K = 1,3                                                           0035
      XLNGTH(K) = 0.0                                                          0036
      IISP(K) = ISP(I,K)                                                       0037
      XXLBAR(K) = XLBAR(I,K)                                                   0038
      DO 915 JJ = 1,3                                                          0039
      FSP(JJ,K) = 0.0                                                          0040
  915 XVOC(JJ,K) = 0.0                                                         0041
  910 CONTINUE                                                                 0042
C LOOP G                                                                       0043
      DO 920 K = 1,3                                                           0044
      IF (IISP(K)) 925,920,925                                                 0045
  925 ISUB = 3*K                                                               0046
      DVC = AI(ISUB)*XXLBAR(K)                                                 0047
      DVCDOT = AIDOT(ISUB)*XXLBAR(K)                                           0048
      VC = VA(3)+DVC                                                           0049
      VCDOT = VADOT(3)+DVCDOT                                                  0050
      C4(K) = VC/DVC                                                           0051
      C5(K) = (DVC*VCDOT-VC*DVCDOT)/(DVC*DVC)                                  0052
      VC3(K) = VC                                                              0053
  920 CONTINUE                                                                 0054
C LOOP H                                                                       0055
      DO 30 K = 1,3                                                            0056
      IF(IISP(K)) 35,30,35                                                     0057
   35 IF(VC3(K)) 30,30,40                                                      0058
   40 ISUB = 3*(K-1)                                                           0059
      BARL = XXLBAR(K)                                                         0060
      SUM = 0.0                                                                0061
      SUMD = 0.0                                                               0062
C LOOP J                                                                       0063
      DO 50 J = 1,3                                                            0064
      ISUB = ISUB+1                                                            0065
      DVC = AI(ISUB)*BARL                                                      0066
      DVCDOT = AIDOT(ISUB)*BARL                                                0067
```

```
      DVP = C4(K)*DVC
      DDP = C4(K)*DVCDOT+C5(K)*DVC
      SUM = SUM+DVP*DVP
      SUMD = SUMD+DVP*DDP
   50 CONTINUE
      SK = SQRT(SUM)
      S(K) = SK
      SC(I,K) = SK
      SDOT(K) = SUMD/SK
C GET LENGTH
      IF(BARL) 55,60,60
   55 T = -BARL-SK
      IF(T) 65,65,70
   70 T = -T
      GO TO 65
   60 T = BARL-SK
      IF(T) 70,65,65
   65 XLNGTH(K) = T
   30 CONTINUE
      PL(1,1) = -SDOT(1)
      PL(2,2) = -SDOT(2)
      PL(3,3) = -SDOT(3)
      PL(2,1) = PBAR(3)*XLNGTH(1)
      PL(3,1) = -PBAR(2)*XLNGTH(1)
      PL(1,2) = -PBAR(3)*XLNGTH(2)
      PL(3,2) = PBAR(1)*XLNGTH(2)
      PL(1,3) = PBAR(2)*XLNGTH(3)
      PL(2,3) = -PBAR(1)*XLNGTH(3)
C LOOP K
      DO 75 JJ = 1,3
      ISUB = JJ-3
      VAD = VADOT(JJ)
C LOOP L
      DO 80 K = 1,3
      IF(IISP(K)) 85,80,85
   85 IF(VC3(K)) 80,80,90
   90 SUM = 0.0
C LOOP M
      DO 95 L = 1,3
      ISUB = ISUB+3
   95 SUM = SUM+AI(ISUB)*PL(L,K)
      VEEDOT(JJ,K) = VAD+SUM
   80 CONTINUE
   75 CONTINUE
C LOOP N
      DO 105 K = 1,3
      IF(IISP(K)) 110,105,110
  110 IF(VC3(K)) 105,105,115
  115 SK = S(K)
      SDIF = SK-SF(I,K)
      IF(SDIF) 120,120,125
  120 IF(IBS(I,K)) 130,130,135
  125 IBS(I,K) = 1
  135 FSPO = FSPOF(I,K)+XKE(I,K)*SDIF
      IF(FSPO) 140,190,190
  140 FSPO = 0.0
      GO TO 190
  130 SP = SK-FSPBAR(I,K)
C FSPBAR = SBAR-FSPOBAR/KE
      IF(SP) 150,155,155
  150 FSPO = 0.0
      GO TO 160
C   COMPUTE FSPO PER NEW EXTERNAL SPRING LOAD-STROKE CURVES 7/25/72
  155 FSPO=FSPOF(I,K)
      IF (SP.GE.SB(I,K))  GO TO 160
      IF (SP.GT.SA(I,K))  GO TO 157
      FSPO=FSPOI(I,K)
      IF (SP.GE.SI(I,K))  GO TO 160
      FSPO=FSPO*SP/SI(I,K)
      GO TO 160
```

```
  157 FSPO=FSPOI(I,K)+(SP-SA(I,K))*(FSPO-FSPOI(I,K))/(SB(I,K)-SA(I,K))
  160 IF(SDOT(K)) 165,165,170
  170 NN(I,K) = 0
      GO TO 190
  165 IF(NN(I,K)) 190,175,190
  175 NN(I,K) = 1
      FSPBAR(I,K) = SK-FSPO/XKE(I,K)
C (15A)
  190 VX = AI(3,K)*FSPO
      XVOC(3,K) = VX
      V1 = VEEDOT(1,K)
      V2 = VEEDOT(2,K)
      VBB = SQRT(V1*V1+V2*V2)
      IF(VBB) 210,210,200
  200 VX = XMU(I,K)*VX/VBB
      XVOC(1,K) = VX*VEEDOT(1,K)
      XVOC(2,K) = VX*VEEDOT(2,K)
  210 IS = 0
C LOOP G
      DO 220 J = 1,3
      SUM = 0.0
C LOOP R
      DO 230 L = 1,3
      IS = IS+1
  230 SUM = SUM+AI(IS)*XVOC(L,K)
  220 FSP(J,K) = SUM
C END OF LOOP N
  105 CONTINUE
C CRASH FORCES
      DO 240 J = 1,3
      SUM = 0.0
      DO 250 K = 1,3
  250 SUM = SUM+FSP(J,K)
  240 XC(J) = SUM
      DXYZ(1)=DX(I)
      DXYZ(2)=DY(I)
      DXYZ(3)=DZ(I)
      DPQRIN(1)=DQIN(I)
      DPQRIN(2)=DRIN(I)
      DPQRIN(3)=DPIN(I)
      DPQRIN(4)=DQIN(I)
      TERM(1) = FSP(3,1)*XLNGTH(1)
      TERM(2) = FSP(1,2)*XLNGTH(2)
      TERM(3) = FSP(2,3)*XLNGTH(3)
      TERM(4) = FSP(2,1)*XLNGTH(1)
      TERM(5) = FSP(3,2)*XLNGTH(2)
      TERM(6) = FSP(1,3)*XLNGTH(3)
C CRASH MOMENTS
      XC(4) = TERM(5)-TERM(3)
      XC(5) = TERM(6)-TERM(1)
      XC(6) = TERM(4)-TERM(2)
C      A1 CORRECTED TO AI IN CALL ON OCT 27,1974        MLH
      CALL MATVEC(AI,DXYZ,DXYZPR,1)
      DO 260 K=1,3
      IF(IISP(K).EQ.0)GO TO 260
      SUM=0.0
      DO 270 J=1,3
  270 SUM=SUM-FSP(J,K)*DXYZPR(J)
      CEIK(I,K)=CEIK(I,K)+SUM+TERM(K)*DPQRIN(K)-TERM(K+3)*DPQRIN(K+1)
  260 CONTINUE
C
      RETURN
      END
!ASS (M:SO,LO)
!ASS (M:CI,DS,S79MAM;F)

!CUP CI,SO
      SUBROUTINE MATMUL(A,B,C)
      IMPLICIT REAL*8(A-H,O-Z)
```

```
      DIMENSION A(3,3),B(3,3),C(3,3)
C A*B TO C
      DO 10 I = 1,3
      DO 10 J = 1,3
      SUM = 0.0
      DO 20 K = 1,3
   20 SUM = SUM+A(I,K)*B(K,J)
   10 C(I,J) = SUM.
      RETURN
      END
!ASS (M:SO,LO)
!ASS (M:CI,D5,S79MAV:F)
```

```
!CUP CI,SO
      SUBROUTINE MATVEC(A,V,P,ISW)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(3,3),V(3),P(3)
C A*V TO P IF ISW = 0, ELSE AT*V TO P
      DO 10 I = 1,3
      SUM = 0.0
      DO 20 K = 1,3
      IF(ISW) 40,30,40
   30 SUM = SUM+A(I,K)*V(K)
      GO TO 20
   40 SUM = SUM+A(K,I)*V(K)
   20 CONTINUE
   10 P(I) = SUM
      RETURN
      END
!ASS (M:SO,LO)
!ASS (M:CI,D5,C75MCH:F)
```

```
!CUP CI,SO
      SUBROUTINE SHELLX(DARRAY,KEY,N)
C       SUBROUTINE MEMBER NAME S79RPO INCLUDES PAPLOT SHELLX FSHELL
      IMPLICIT REAL*8(A-H,O-Z)
C
C       THIS IS A FORTRAN SUBROUTINE FOR RE-ORDERING A DEPENDENT ARRAY AC-
C CORDING TO THE KEY PRODUCED BY SUBROUTINE SHELL WHEN AN INDEPENDENT
C ARRAY WAS SORTED.  THUS, THE ROUTINE WILL RETURN THE DEPENDENT ARRAY
C IN ITS ORIGINAL CORRESPONDENCE WITH THE INDEPENDENT ARRAY.  DARRAY IS
C THE NAME OF THE DEPENDENT ARRAY (DIMENSIONED AT LEAST N IN THE CALLING
C PROGRAM), KEY IS THE NAME OF THE KEY ARRAY (DIMENSIONED AT LEAST N IN
C THE CALLING PROGRAM), AND N IS THE NUMBER OF ELEMENTS IN DARRAY AND IN
C KEY.  GIVEN THE ARRAYS KEY AND DARRAY,
C
C                       KEY(1)    DARRAY(1)
C                       KEY(2)    DARRAY(2)
C                         .          .
C                         .          .
C                         .          .
C                       KEY(N)    DARRAY(N),
C
C IT IS DESIRED TO RE-ORDER DARRAY TO YIELD
C
C                       KEY(1)    DARRAY(KEY(1))
C                       KEY(2)    DARRAY(KEY(2))
C                         .          .
C                         .          .
C                         .          .
C                       KEY(N)    DARRAY(KEY(N)).
```

```
C
C THIS SUBROUTINE ASSUMES KEY IS THE SAME ARRAY WHICH WAS PASSED TO SUB-
C ROUTINE SHELL, WHICH PLACED IN KEY THE POSITIVE INTEGERS FROM 1
C THROUGH N. IF KEY IS OTHERWISE, A DISASTER SHOULD BE EXPECTED.
C     ALTHOUGH THIS FORTRAN ROUTINE REQUIRES MORE EXECUTION TIME THAN A
C COMPARABLE MACHINE-DEPENDENT ROUTINE, IT DOES POSSESS THE FLEXIBILITY
C FOR A RAPID IMPLEMENTATION ON COMPUTERS PROCESSING FORTRAN. THE TIMES
C REQUIRED TO RE-ORDER A DARRAY OF 10000 ELEMENTS ON THE SRU 1108 WERE;
C
C                 A SLEUTH II ROUTINE  - .100 SECONDS,
C                 THIS FORTRAN ROUTINE - .169 SECONDS.
C
C CODING BY T.M.JONSON OF THE BOEING COMPANY, APRIL 1967.
C
C
      DIMENSION DARRAY(1),KEY(1)
C
C     SET IFIRST=1.  IFIRST REFERENCES THE FIRST ELEMENT IN KEY WHICH IS
C NOT KNOWN TO HAVE ITS PROPER DARRAY ELEMENT IN CORRESPONDENCE WITH IT.
C
      IFIRST=1
C
C     FIND THE SMALLEST I, IFIRST.LE.I.LE.NT SUCH THAT KEY(I) IS POSI-
C TIVE (INITIALLY, ALL KEY(I) SHOULD BE POSITIVE, AND HENCE I=1). THOSE
C KEY(I) WHICH ARE NEGATIVE ARE IGNOREDT AS THEY ALREADY HAVE THE PROPER
C ELEMENTS FROM DARRAY IN CORRESPONDENCE WITH THEM.
C
   10 DO 20 I=IFIRST,N
      IF(KEY(I))20,20,40
   20 CONTINUE
C
C     NO SUCH I EXISTS, WHICH IMPLIES THAT THE RE-ORDERING HAS BEEN COM-
C PLETED. RESET ALL KEY(I) TO POSITIVE, AND RETURN TO THE CALLING PRO-
C GRAM.
C
      DO 30 I=1,N
   30 KEY(I)=-KEY(I)
      RETURN
C
C     SET IFIRST=I, WHICH WAS FOUND ABOVE.  FOR ALL KEY(I) SUCH THAT
C I.LT.IFIRST, IT IS KNOWN THAT THE PRO-E- DARRAY ELEMENT IS IN CORRE-
C SPONDENCE.  ALSO, SET TEMP=DARRAY(I).  SINCE THE ORIGINAL CONTENTS OF
C DARRAY(I) ARE BEING HELD IN TEMP, THE LOCATION IS AVAILABLE FOR THE
C PROPER ELEMENT OF DARRAY WHICH IS TO COR-ESPOND TO KEY(I).
C
   40 IFIRST=I
      TEMP=DARRAY(I)
      GO TO 60
C
C     PLACE THE PROPER ELEMENT FROM DAR-AY INTO CORRESPONDENCE WITH
C KEY(I).  SINCE IK=KEY(I) FROM A LOGICALLY PREVIOUS STATEMENT, THE
C PROPER ELEMENT IS DARRAY(IK).  SINCE THIS ELEMENT HAS BEEN PROPERLY
C PLACED, ITS ORIGINAL LOCATION IS NOW 5VACANT'.  HENCE, SET I=IK TO
C REFERENCE THIS 'VACANT' LOCATION.
C
   50 DARRAY(I)=DARRAY(IK)
      I=IK
C
C     THE PROPER ELEMENT TO CORRESPOND OITS KEY(I) IS DARRAY(IK), WHERE
C IK=KEY(I).  ALSO, MAKE KEY(I) NEGATIVE, SO THAT IT IS FLAGGED AS HAV-
C ING THE PROPER ELEMENT FROM DARRAY IN CO-RESPONDENCE WITH IT.
C
   60 IK=KEY(I)
      KEY(I)=-IK
C
C     IK MUST BE COMPARED WITH IFIRST.
C
      IF(IK-IFIRST)50,70,50
C
C     SINCE IK=IFIRST, THE PROPER ELEME-T FROM DARRAY TO CORRESPOND WITH
```

```
C KEY(I) IS IN TEMP.  BUT PLACING TEMP IN ITS PROPER LOCATION WILL NOT
C CREATE A 'VACANCY' IN DARRAY.  HENCE, THIS 'CYCLE' HAS BEEN PROPERLY
C RE-ORDERED, AND A NEW 'CYCLE' MUST BE FOUND.
C
   70 DARRAY(I)=TEMP
      GO TO 10
      END
      SUBROUTINE FSHELL(ARRAY,KEY,N)
      IMPLICIT REAL*8(A-H,O-Z)                                          0002
C
C     THIS IS A FORTRAN SUBROUTINE FOR SORTING AN INDEPENDENT ARRAY OF
C SIZE N INTO ASCENDING ORDER (ALGEBRAICALLY LEAST FIRST), AND PROVIDING
C A 'KEY' ARRAY WHICH WILL ALLOW SUBROUTINE SHELLX TO RETURN DEPENDENT
C ARRAYS TO THEIR ORIGINAL CORRESPONDENCE WITH THE INDEPENDENT ARRAY.
C IARRAY IS THE NAME OF THE INDEPENDENT ARRAY (DIMENSIONED AT LEAST N IN
C THE CALLING PROGRAM), KEY IS THE NAME OF THE KEY ARRAY (DIMENSIONED AT
C LEAST N IN THE CALLING PROGRAM), AND N IS THE NUMBER OF ELEMENTS IN
C IARRAY AND KEY.
C     THE SUBROUTINE USES THE ALGORITHM PRESENTED IN THE COMM. ACM, JULY
C 1959, BY D.L.SHELL OF THE GENERAL ELECTRIC COMPANY.  ALTHOUGH THIS
C FORTRAN ROUTINE REQUIRES MORE EXECUTION TIME THAN A COMPARABLE MACHINE
C DEPENDENT ROUTINE, IT DOES POSSESS THE FLEXIBILITY FOR A RAPID IMPLE-
C MENTATION ON COMPUTERS PROCESSING FORTRAN.  THE TIMES REQUIRED TO SORT
C AN IARRAY OF 10000 ELEMENTS ON THE SRU 1108 WERE:
C
C                    A SLEUTH II ROUTINE  - 1.603 SECONDS
C                    THIS FORTRAN ROUTINE - 4.053 SECONDS
C
C CODING BY T.M.JONSON OF THE BOEING COMPANY, APRIL 1967.
C
C
      DIMENSION  ARRAY(1),KEY(1)
C
C     ESTABLISH THE INITIAL CONDITION OF THE KEY ARRAY.  KEY IS FILLED
C WITH THE SEQUENTIAL INTEGERS 1,2,...,N.  THUS, KEY REPRESENTS THE
C ORIGINAL LOCATIONS OF THE ELEMENTS IN IARRAY.  AS IARRAY IS SORTED,
C THE CORRESPONDING ELEMENTS IN KEY WILL BE MOVED TO REFLECT THIS RE-
C LOCATION.  AFTER THE SORT IS COMPLETET KEY WILL ALLOW SUBROUTINE
C SHELLX TO RE-ORDER DEPENDENT ARRAYS INTO THEIR ORIGINAL CORRESPONDENCE
C WITH IARRAY.
C
      DO 10 I=1,N
   10 KEY(I)=I
C
C     ESTABLISH THE INITIAL CONDITION FOR M.  M IS THE CURRENT NUMBER OF
C SUBSETS INTO WHICH IARRAY HAS BEEN PARTITIONED.
C
      M=N
C
C     REDUCE M.  WHEN THE ALGORITHM PROCEEDS WITH THE REDUCED M, THE
C EFFECT IS A MERGE OF THE OLD SUBSETS INTO ABOUT HALF AS MANY NEW.  IN-
C ITIALLY, IARRAY IS PARTITIONED INTO ABOUT N/2 SUBSETS, EACH OF WHICH
C CONTAINS 2 ELEMENTS, WITH THE EXCEPTION THAT ONE SUBSET WILL CONTAIN 3
C ELEMENTS IF N IS ODD.  IT IS RECOMMENDED THAT A SAMPLE PROBLEM BE
C WORKED BY HAND TO UNDERSTAND THE MECHANISM OF THE PARTITIONING.
C
   20 M=M/2
C
C     TEST THE REDUCED M.  IF M IS ZERO, THE ENTIRE IARRAY HAS BEEN
C SORTED, AND CONTROL IS RETURNED TO THE CALLING PROGRAM.
C
      IF(M)30,30,40
   30 RETURN
C
C     SET K=N-M.  THE ELEMENTS IN IARRAY FROM IARRAY(1) TO IARRAY(K)
C WILL BE USED AS 'BASE' ELEMENTS FOR COMPARISONS.  THAT IS, IARRAY(I)
C WILL BE COMPARED WITH IARRAY(I+M).  THUS, ALL ELEMENTS IN IARRAY WILL
C ENTER THE COMPARISON SEQUENCE.
C
   40 K=N-M
```

```
      DO 70 J=1,K
C
C     SINCE THE INDEX ADDRESSING THE 'BASE' ELEMENT MAY BE MODIFIED
C 'BACKWARDS' BY THE FOLLOWING CODE, SET I=J AND USE I FOR THE 'BASE'
C INDEX.  THIS PRESERVES THE CORRECT VALUE OF J FOR THE NEXT 'BASE'.
C
      I=J
C
C     II IS CREATED TO REFERENCE THE NEXT HIGHEST ELEMENT IN THE CURRENT
C SUBSET, WHICH IS TO BE COMPARED WITH IARRAY(I).
C
   50 II=I+M
C
C     COMPARE  ARRAY(I) WITH  ARRAY(II).
C
      IF( ARRAY(I)- ARRAY(II))70,70,60
C
C     SINCE IARRAY(I) IS GREATER THAN IARRAY(II), INTERCHANGE THESE TWO
C ELEMENTS, MOVING THE SMALLER TOWARD THE FIRST OF THE ARRAY.  ALSO, IN-
C TERCHANGE KEY(I) AND KEY(II) TO REFLECT THE NEW LOCATIONS OF THESE
C ELEMENTS.
C
   60 TIMBO= ARRAY(I)
       ARRAY(I)= ARRAY(II)
       ARRAY(II)=TIMBO
      TIMBO=KEY(I)
      KEY(I)=KEY(II)
      KEY(II)=TIMBO
C
C     SINCE AN INTERCHANGE OCCURRED, THE ELEMENT IN IARRAY(I) MUST NOW
C BE COMPARED WITH THE OTHER ELEMENTS IN ITS SUBSET OCCUPYING LOWER LO-
C CATIONS IN IARRAY.  THE COMPARISONS AND EXCHANGES CONTINUE UNTIL THE
C ELEMENT HAS BEEN PROPERLY ORDERED IN ITS SUBSET.  I IS REDUCED BY M TO
C REFERENCE THE NEXT LOWER ELEMENT, AND THEN TESTED TO ASSURE I.GE.1.
C
      I=I-M
      IF(I)70,70,50
C
C     THE ELEMENT IS PROPERLY PLACED IN ITS SUBSET.  EXAMINE THE NEXT
C 'BASE' ELEMENT.
C
   70 CONTINUE
C
C     ALL OF THE M SUBSETS HAVE BEEN SORTED.
C
      GO TO 20
      END
!ASS (M:SO,LO)
!ASS (M:CI,D5,S79PAP:F)


!CUP CI,SO
      SUBROUTINE PAPLOT( V, W, NPTS, ISCALE)
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*4 S,G
C     MEMBERNAME S79PAP
C **  SUBROUTINE TO GENERATE ONLINE PAPER PLOTS                         0005
      DIMENSION V(1), W(1), S(103), BX(500), G(6), X(101), Y(101)       0006
      DATA S(1),S(103)/'(9X,',' )  '/,G(1),G(2),G(3),G(4),G(5),G(6)/'1X,0007
     1','1H.','1H*','1H-','1H+','INCH'/                                 0008
C **  SET UP SCALE VALUES FOR INDEPENDANT 'X' ARRAY                     0009
      AMAX1(C,D)= DMAX1(C,D)                                            0114
      AMIN1(C,D)= DMIN1(C,D)                                            0115
      ABS(C)= DABS(C)                                                   0116
      XMAX = -1.0E10                                                    0010
      YMAX = -1.0E10                                                    0011
```

```
      XMIN = 1.0E10                                                     0012
      YMIN = 1.0E10                                                     0013
      DO 10 I = 1 , NPTS                                                0014
      XMAX = AMAX1( V(I), XMAX)                                         0015
      XMIN = AMIN1( V(I),XMIN )                                         0016
      YMAX = AMAX1( W(I), YMAX )                                        0017
      YMIN = AMIN1( W(I), YMIN )                                        0018
      X( I ) = V( I )                                                   0019
      Y( I ) = W( I )                                                   0020
 10   CONTINUE                                                          0021
      DX = XMAX - XMIN                                                  0022
      DY = YMAX - YMIN                                                  0023
C-------------------------------OPTIONS---------------------------- 0023
C-------IF ISCALE=1 SELECT SCALES INDEPENDENTLY BASED ON X AND Y------- 0023
C------IF ISCALE=0 SELECT SCALES OF EQUAL MAGNITUDE  ---------------- 0023
      IF(ISCALE.EQ.1) GO TO 118                                         0023
         IF(DY.GT.DX) DX=DY                                             0135
         IF(DX.GT.DY) DY=DX                                             0136
 118  X1=XMIN                                                           0026
      XSCALE=DX*0.10                                                    0027
C **  REORDER  DEPENDANT 'Y' ARRAY IN MONOTONICALLY INCREASING MAGNITUDE0028
      CALL FSHELL (Y,BX,NPTS)                                           0029
C **  REORDER  INDENDANT 'X' ARRAY IN CORRESPONCE WITH PRESENT 'Y' ARRAY0030
      CALL SHELLX (X,BX,NPTS)                                           0031
C **  SETUP SCALE VALUES FOR DEPENDANT 'Y' ARRAY                        0032
      YSCALE=DY/8.333333                                                0033
C **  INDEX PRINTER TWO LINES DOWN ON NEW PAGE                          0034
C     WRITE(6,7000)
C-------- LINE LOCATES HORIZONTAL AXIS ---------------------------      0036
      IF(Y(1).GT.0.) LINE=1                                             0037
      IF(Y(1).LT.0..AND.Y(NPTS).LT.0.) LINE=50                          0038
      IF(Y(1).LT.0..AND.Y(NPTS).GT.0.) LINE=ABS(Y(1))/DY*50.            0039
C **  LOCATE FIRST VERTICAL SCALE MARK                                  0044
C-----------MARK LOCATES '-' IN VERTICAL SCALE---------------------     0044
      MARK=50-LINE-(50-LINE)/6*6                                        0045
      J=1                                                               0046
      N=1                                                               0047
      NL=51                                                             0048
C **  START LINE LOOP                                                   0049
 100  CONTINUE                                                          0050
C **  SETUP I1 & I2 FOR NORMAL PRINT LINE                               0051
      I1=1                                                              0052
      I2=3                                                              0053
      IF((NL-1).NE.LINE)GO TO 125                                       0054
C **  SETUP I1 & I2 FOR ZERO AXIS PRINT LINE                            0055
      I1=4                                                              0056
      I2=5                                                              0057
 125  CONTINUE                                                          0058
      DO 150 I=3,102                                                    0059
      S(I)=G(I1)                                                        0060
 150  CONTINUE                                                          0061
      S(2)=G(I2)                                                        0062
C                                                                       0064
C-----------PUT HORIZONTAL SCALE MARKS IN 'S' ARRAY----------------     0064
C                                                                       0064
      IF((NL-1).NE.LINE) GO TO 160                                      0064
      DO 155 I1=12,102,10                                               0064
 155  S(I1)=G(3)                                                        0064
 160  CONTINUE                                                          0064
C*****   IDENTIFY CURRENT PRINT LINE NUMBER   ********                  0064
      NL=51-N                                                           0064
C **  START DIMINISHING LOOP ON DEPENDANT ARRAY LINE I.D.               0065
      DO 250 I2=J,NPTS                                                  0066
      K=NPTS-I2+1                                                       0067
      M=(Y(K)-Y(1))/DY*50+0.0833333                                     0068
      IF(M.EQ.0.AND.ISCALE.EQ.1) M=1                                    0068
         IF(K.EQ.1.AND.NL.EQ.1.AND.ISCALE.EQ.0) GO TO 200               0185
         IF(K.EQ.1.AND.NL.NE.1.AND.ISCALE.EQ.0) GO TO 250               0185
      IF(M.EQ.0)M=1                                                     0068
      IF(M-NL)260,200,175                                               0069
```

```
 175  WRITE(6,7010)I2,K,M,NL,Y(K)                                   0070
C **  ERROR IN M CALCULATION                                        0071
      GO TO 240                                                     0072
 200  CONTINUE                                                      0073
C **  CALCULATE LOCATION IN S ARRAY FOR DATA POINT I.D.             0074
      I1=(X(K)-X1)/DX*100+2.05                                      0075
      S(I1)=G(2)                                                    0076
 240  CONTINUE                                                      0077
 250  CONTINUE                                                      0078
      J=NPTS                                                        0079
      GO TO 275                                                     0080
 260  J=I2                                                          0081
 275  N=N+1                                                         0082
C **  TEST FOR SCALE MARK LOCATION                                  0083
      IF(MARK.NE.0)GO TO 350                                        0084
C **  PLACE VERTICAL SCALE MARK IN 'S' ARRAY                        0087
      IF(S(2).NE.G(2)) S(2)=G(4)
C **  RESET MARK INDEX                                              0095
 340  MARK=6                                                        0096
 350  CONTINUE                                                      0097
C **  GENERATE ONE LINE OF PLOTTING                                 0098
      WRITE(6,S)                                                    0099
C **  DECREMENT MARK INDEX                                          0100
      MARK=MARK-1                                                   0101
C **  TEST FOR LAST LINE TO DETERMINE PLOT IS COMPLETED             0102
      IF(NL.GT.1) GO TO 100                                         0103
C **  END OF PLOT.  PRINT MAXIMUMS,MINIMUMS & SCALES                0104
      WRITE(6,7020) XMAX,XMIN,XSCALE,YMAX,YMIN,YSCALE
      RETURN
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C                                  FORMATS
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 7000 FORMAT(1H1//)
 7010 FORMAT(9X,'ERROR  M IS GREATER THAN NL  I= ',I3,'  K= ',I3,'  M= '
     1,I3,'  NL= ',I2,'  Y(K)= ',G12.6)
 7020 FORMAT(36X,'XMAX   ',G12.6,'  ***  XMIN   ',G12.6,'  ***  XSCALE  ',
     1G12.6/36X,'YMAX   ',G12.6,'  ***  YMIN   ',G12.6,'  ***  YSCALE  ',
     2G12.6)
      END
!ASS (M:SO,LO)
!ASS (M:CI,D5,S79RDO:F)
```

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```
!CUP CI,SO
      SUBROUTINE TMCK                                               0001
      IMPLICIT REAL*8(A-H,O-Z)
C     MEMBER NAME S79RTMCK                                          0002
C      MEMBER NAME S79RTMCK TAKEN FROM S79RDERV                     0003
C     THIS ROUTINE IS ONLY ENTERED IF INPUT PARAMETER ATMCK IS GREATER 0003
C     THAN 0.0                                                      0003
C     THIS ROUTINE CALCULATES FREQUENCY                             0003
C NOTE FOR DOUBLE PRECISION T TEST IN LINE 00620000 SHOULD BE 'E10' 0004
      REAL*4 XKS,XKI,XKR,AXK,CHUG                                   0009
      INTEGER*4 BLANK                                               0006
      DIMENSION FREQ(50,6)
      DIMENSION SINCOS(6),CIJ(450),DAI(9),DD(6),DF(6),D(6),AIAIJT(9),
     1 AP(9),SIGF(6,85)
      COMMON /BLANK1/ XX(50),XY(50),XZ(50),XL(50),XM(50),           0006
     1 XN(50),DPX(50),DPY(50),DPZ(50),DPL(50),DPM(50),DPN(50),PIN(50), 0007
     2 QIN(50),RIN(50),XI1(50),XI2(50),XI3(50),XI4(50),XI5(50),XI6(50), 0008
     3 XXK(085),XYK(085),XZK(085),XLK(085),XMK(085),XNK(085),XXJ(085), 0009
     4 XYJ(085),XZJ(085),XLJ(085),XMJ(085),XNJ(085),                0010
     5    DELI(50),POLD(50),QOLD(50),ROLD(50),UOLD(50),VOLD(50),    0011
     6 WOLD(50),XOLD(50),YOLD(50),ZOLD(50),PINO(50),QINO(50),RINO(50), 0012
     7 OXIJ(085),OYIJ(085),OZIJ(085),PHIOLD(50),THEOLD(50),PSIOLD(50), 0013
     8 TPEN(085),TRUPT(085),DTHALF                                  0014
```

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      COMMON/COMALL/ C(6,085),P(50),Q(50),R(50),U(50),V(50),W(50),X(50),0017
     1 Y(50),Z(50),AI(9),AJ(9),XKREF(6,85),SC(50,3),XC(6),
     A XK(3060),XI(50),
     2YI(50),ZI(50),XYI(50),XZI(50),YZI(50),AIJ(9),BIJ(450),DIJ(765),
     3 CRI(085),OAI(450),VEL(510),WGT(50),PHI(50),THETA(50),PSI(50),    0020
     4 PDOT(50),QDOT(50),RDOT(50),UDOT(50),VDOT(50),WDOT(50),XDOT(50),  0021
     5 YDOT(50),ZDOT(50),PHIDOT(50),THEDOT(50),PSIDOT(50),TIME,DELTAT,  0022
     6XACC(50),YACC(50),ZACC(50),AITAJ(9),AIDOT(9),FMBAR(6,85),
     A DELFMO(3060),
     7 PHIIJ(085),THEIJ(085),PSIIJ(085),SUMDF(6,085),TITLE(20),         0024
     8 XLBAR(50,3),FSPBAR(50,3),VEEDOT(3,3),DX(50),DY(50),DZ(50),       0025
     8 DPIN(50),DQIN(50),DRIN(50),                                      0026
     8           SEIJ(085),DEIJ(085),CEIK(50,3), TMAX                    0027
      COMMON / ICOMAL/ MAXNM,MAXIGS,MAXTBL,INDP,                         0028
     A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085), 0029
     B N(510),NN(50,3),ISP(50,3),IJPR(085),IDPLOT(010)                  0030
      DATA BLANK/'    '/                                                0042
      SQRT(G)= DSQRT(G)                                                 0040
      SIN(G)= DSIN(G)                                                   0041
      COS(G)= DCOS(G)                                                   0042
      ABS(G)= DABS(G)                                                   0043
      FRQ=0.                                                            0044
C DO ALL THE (AI)((AJ))                                                 0045
      DO 2000 IMASS=1,NM                                                0046
      I=IMASS                                                           0047
C                                                                       0064
      J = 9*(I-1)                                                       0065
C MOVE AI S TO OLD AI S                                                 0066
      DO 4 JJ = 1,9                                                     0067
      AI(JJ)=BIJ(J+JJ)
    4 OAI(J+JJ) = BIJ(J+JJ)                                             0068
C (27)                                                                  0089
C DO 1000 IS MAIN DO LOOP TO GET TOTAL INTERNAL FORCES AND MOMENTS      0090
      ILAST = 0                                                         0091
      IJLIJ = 0                                                         0092
      IJKLIJ = -36                                                      0093
      DO 1000 IJ = 1,IGS                                                0094
      IJKLIJ = IJKLIJ+36                                                0095
      IJKK = IJKLIJ-6                                                   0096
      IJLIJ = IJLIJ+6                                                   0097
      IJL = IJLIJ                                                       0098
      I = IG(IJ)                                                        0099
      J = JG(IJ)                                                        0100
C*****CALCULATE CONNECTIVITY                                            0101
      IF(I.NE.IMASS.AND.J.NE.IMASS) GO TO 1000                          0102
C IF WE GET TO A NEW I WE MUST MOVE (AI) INTO AI AND (AIDOT) INTO AIDOT 0103
      IF(I-ILAST) 20,30,20                                              0104
   20 ILAST = I                                                         0105
      IS = 9*(I-1)                                                      0106
      DO 320 KS = 1,9                                                   0107
      IS = IS+1                                                         0108
      DAI(KS) = OAI(IS)-BIJ(IS)                                         0109
  320 AI(KS) = BIJ(IS)                                                  0110
   30 XIJO=OXIJ(IJ)
      YIJO = OYIJ(IJ)                                                   0115
      ZIJO = OZIJ(IJ)                                                   0116
      XIJ=X(J)-X(I)
      YIJ=Y(J)-Y(I)
      ZIJ=Z(J)-Z(I)
C                                                                       0117
      IS = 9*(J-1)                                                      0118
      IJS = 9*(IJ-1)                                                    0119
      DO 310 KS = 1,9                                                   0120
      IS = IS+1                                                         0121
      IJS = IJS+1                                                       0122
      AIJ(KS) = DIJ(IJS)                                                0123
  310 AJ(KS) = BIJ(IS)                                                  0124
C  (4)  PERTURB IMASS UNIT DEFLECTION +1                                0125
      DX(IMASS)=1.                                                      0125
      DY(IMASS)=1.                                                      0125
```

```
      DZ(IMASS)=1.
      T1=DX(J)-DX(I)
      T2=DY(J)-DY(I)
      T3=DZ(J)-DZ(I)
C (5)
      T4= AI(1)*T1+AI(2)*T2+AI(3)*T3-DAI(1)*XIJ0-DAI(2)*YIJ0-DAI(3)*ZIJ0
      T5= AI(4)*T1+AI(5)*T2+AI(6)*T3-DAI(4)*XIJ0-DAI(5)*YIJ0-DAI(6)*ZIJ0
      T6= AI(7)*T1+AI(8)*T2+AI(9)*T3-DAI(7)*XIJ0-DAI(8)*YIJ0-DAI(9)*ZIJ0
      D(1) = AIJ(1)*T4+AIJ(2)*T5+AIJ(3)*T6
      D(2) = AIJ(4)*T4+AIJ(5)*T5+AIJ(6)*T6
      D(3) = AIJ(7)*T4+AIJ(8)*T5+AIJ(9)*T6
C (9)
      AITAJ(1) = AI(1)*AJ(1)+AI(2)*AJ(2)+AI(3)*AJ(3)
      AITAJ(2) = AI(4)*AJ(1)+AI(5)*AJ(2)+AI(6)*AJ(3)
      AITAJ(3) = AI(7)*AJ(1)+AI(8)*AJ(2)+AI(9)*AJ(3)
      AITAJ(4) = AI(1)*AJ(4)+AI(2)*AJ(5)+AI(3)*AJ(6)
      AITAJ(5) = AI(4)*AJ(4)+AI(5)*AJ(5)+AI(6)*AJ(6)
      AITAJ(6) = AI(7)*AJ(4)+AI(8)*AJ(5)+AI(9)*AJ(6)
      AITAJ(7) = AI(1)*AJ(7)+AI(2)*AJ(8)+AI(3)*AJ(9)
      AITAJ(8) = AI(4)*AJ(7)+AI(5)*AJ(8)+AI(6)*AJ(9)
      AITAJ(9) = AI(7)*AJ(7)+AI(8)*AJ(8)+AI(9)*AJ(9)
C PERTURB IMASS UNIT ROTATION
      DPIN(IMASS)=1.
      DQIN(IMASS)=1.
      DRIN(IMASS)=1.
      T3 = DRIN(J)
      T2 = DQIN(J)
      T1 = DPIN(J)
      T4 = T1*AITAJ(1)+T2*AITAJ(4)+T3*AITAJ(7)-DPIN(I)
      T5 = T1*AITAJ(2)+T2*AITAJ(5)+T3*AITAJ(8)-DQIN(I)
      T6 = T1*AITAJ(3)+T2*AITAJ(6)+T3*AITAJ(9)-DRIN(I)
C (9R)
      D(4) = AIJ(1)*T4+AIJ(2)*T5+AIJ(3)*T6
      D(5) = AIJ(4)*T4+AIJ(5)*T5+AIJ(6)*T6
      D(6)= AIJ(7)*T4+AIJ(8)*T5+AIJ(9)*T6
      DX(IMASS)=0.
      DY(IMASS)=0.
      DZ(IMASS)=0.
      DPIN(IMASS)=0.
      DQIN(IMASS)=0.
      DRIN(IMASS)=0.
C*****FMBAR HAS VDBAR(I,J,K,L) IN IT NOW (7AUG1972)
      DO 150 K = 1,6
      IJKK = IJKK+6
      IJKL = IJKK
      IJL = IJL-6
      DF(K) = 0.0
      DO 150 L = 1,6
      IJKL = IJKL+1
      IJL = IJL+1
      T = XK(IJKL)
      IF(T) 160,150,160
  160 A = D(L)
  190 DELFM = T*A
C*****FOR DECOUPLED FREQUENCIES
      IF(K.GT.3.AND.L.GT.3) DF(K)=DF(K)+DELFM
      IF(K.LT.4.AND.L.LT.4) DF(K)=DF(K)+DELFM
  150 CONTINUE
      DO 9000 K=1,6
 9000 D(K)=DF(K)
      AIAIJT(1) = AI(1)*AIJ(1)+AI(4)*AIJ(2)+AI(7)*AIJ(3)
      AIAIJT(4) = AI(1)*AIJ(4)+AI(4)*AIJ(5)+AI(7)*AIJ(6)
      AIAIJT(7) = AI(1)*AIJ(7)+AI(4)*AIJ(8)+AI(7)*AIJ(9)
      AIAIJT(2) = AI(2)*AIJ(1)+AI(5)*AIJ(2)+AI(8)*AIJ(3)
      AIAIJT(5) = AI(2)*AIJ(4)+AI(5)*AIJ(5)+AI(8)*AIJ(6)
      AIAIJT(8) = AI(2)*AIJ(7)+AI(5)*AIJ(8)+AI(8)*AIJ(9)
      AIAIJT(3) = AI(3)*AIJ(1)+AI(6)*AIJ(2)+AI(9)*AIJ(3)
      AIAIJT(6) = AI(3)*AIJ(4)+AI(6)*AIJ(5)+AI(9)*AIJ(6)
      AIAIJT(9) = AI(3)*AIJ(7)+AI(6)*AIJ(8)+AI(9)*AIJ(9)
C (13A)
```

```
      T1 = AIAIJT(1)*D(1)+AIAIJT(4)*D(2)+AIAIJT(7)*D(3)
      T2 = AIAIJT(2)*D(1)+AIAIJT(5)*D(2)+AIAIJT(8)*D(3)
      T3 = AIAIJT(3)*D(1)+AIAIJT(6)*D(2)+AIAIJT(9)*D(3)
      D(1) = T1
      D(2) = T2
      D(3) = T3
C (13B)
      T1 = AIAIJT(1)*D(4)+AIAIJT(4)*D(5)+AIAIJT(7)*D(6)
      T2 = AIAIJT(2)*D(4)+AIAIJT(5)*D(5)+AIAIJT(8)*D(6)
      T3 = AIAIJT(3)*D(4)+AIAIJT(6)*D(5)+AIAIJT(9)*D(6)
      D(4) = T1
      D(5) = T2
      D(6) = T3
      IF(I.EQ.IMASS) GO TO 181
C (17A)
      DXX = -(AJ(1)*D(1)+AJ(2)*D(2)+AJ(3)*D(3))
      DXY = -(AJ(4)*D(1)+AJ(5)*D(2)+AJ(6)*D(3))
      DXZ = -(AJ(7)*D(1)+AJ(8)*D(2)+AJ(9)*D(3))
      XX(J) = XX(J)+DXX
      XY(J) = XY(J)+DXY
      XZ(J) = XZ(J)+DXZ
C (17B)
      DXL = -(AJ(1)*D(4)+AJ(2)*D(5)+AJ(3)*D(6))
      DXM = -(AJ(4)*D(4)+AJ(5)*D(5)+AJ(6)*D(6))
      DXN = -(AJ(7)*D(4)+AJ(8)*D(5)+AJ(9)*D(6))
      XL(J) = XL(J)+DXL
      XM(J) = XM(J)+DXM
      XN(J) = XN(J)+DXN
  181 IF(J.EQ.IMASS) GO TO 1000
C (14B)
C           TRANSFER OF MOMENTS NOT REQ'D       EW  9-3-76
C (16A)
      DXX = AI(1)*D(1)+AI(2)*D(2)+AI(3)*D(3)
      DXY = AI(4)*D(1)+AI(5)*D(2)+AI(6)*D(3)
      DXZ = AI(7)*D(1)+AI(8)*D(2)+AI(9)*D(3)
      XX(I) = XX(I)+DXX
      XY(I) = XY(I)+DXY
      XZ(I) = XZ(I)+DXZ
C (16B)
      DXL = AI(1)*D(4)+AI(2)*D(5)+AI(3)*D(6)
      DXM = AI(4)*D(4)+AI(5)*D(5)+AI(6)*D(6)
      DXN = AI(7)*D(4)+AI(8)*D(5)+AI(9)*D(6)
      XL(I) = XL(I)+DXL
      XM(I) = XM(I)+DXM
      XN(I) = XN(I)+DXN
 1000 CONTINUE
C FINISH COMPUTING DERIVATIVES
      I=IMASS
C DO CRASH FORCES
      DO 340 K = 1,6
  340 XC(K) = 0.0
C (20),(23),(24)
      SX=XX(I)+XC(1)
      SY=XY(I)+XC(2)
      SZ=XZ(I)+XC(3)
      SL = XL(I)+XC(4)
      SM = XM(I)+XC(5)
      SN = XN(I)+XC(6)
C MASS
      PP=P(I)
      RR=R(I)
      QQ=Q(I)
      WGTI=386./WGT(I)
      FREQ(I,1)=(ABS(SX*WGTI))**.5
      FREQ(I,2)=(ABS(SY*WGTI))**.5
      FREQ(I,3)=(ABS(SZ*WGTI))**.5
C (26)
      FREQ(I,4)=(ABS(SL/XI(I)))**.5
      FREQ(I,5)=(ABS(SM/YI(I)))**.5
      FREQ(I,6)=(ABS(SN/ZI(I)))**.5
```

```
9060 DO 7995  KK=1,6                                                    0273
7995 IF(FREQ(I,KK).GT.SEIJ(I)) SEIJ(I)=FREQ(I,KK)                       0274
     IF(SEIJ(I).GT.FRQ) FRQ=SEIJ(I)                                     0275
2000 CONTINUE                                                           0276
     FRQ=FRQ/6.283192
     PERIOD=1.0/FRQ
     PER4TH=PERIOD/4.                                                   0278
     PRINT 7999, FRQ,PERIOD,PER4TH                                      0279
7999 FORMAT(1H1,80(1H*)//2X,'MAXFREQ=',F6.1,'HZ',6X,'PERIOD=',F8.6,
   1 6X,'PER4TH=',F8.6)
     PRINT 8003
     PRINT 8000                                                         0282
8000 FORMAT (2X,'MASS'4X,'OMEGA 1              2              3         4',0283
   1'            5              6         MAX')                         0284
     PRINT 8002,(KK,(FREQ(KK,LL),LL=1,6),SEIJ(KK),KK=1,NM)              0285
     PRINT 8003                                                         0285
8003 FORMAT(2X,80(1H*))
8002 FORMAT(1X,I6,4X,7F12.2)                                            0286
     RETURN                                                             0291
     END                                                                0292
!ASS (M:SO,LO)
!ASS (M:CI,D5,S79RAM;F)


!CUP CI,SO
      SUBROUTINE RSTRT (RSTIME,XPRS,NCODE)                              0001
      IMPLICIT REAL*8(A-H,O-Z)
C       MEMBER NAME S79RSTRT                                            0002
      REAL*4 KR(15),SLOPE,XKS,XKI,XKR,CHUG                              0004
      INTEGER*4 XMA,YIELD,PLAST
      DIMENSION BLK1(3296),IBLK(258),XMA(152),COML(13528),ICOM(1098),
     1 D74(1200),DER(863),DER1(4),XI74(7),ING(1019),IDER(170)
      DIMENSION COM(3206),ICO(258)
      DIMENSION PLY(1700),IPLY(680)
      DIMENSION VARC(9)
      DIMENSION DLG(170)
      DIMENSION NPLT(213),SSTIT(101)
      COMMON/VARSTP/ DELTMN,DELSV,EER,EEG,EROT,ERROR
     1,TMX,TTMX,TTTMX
      DIMENSION ICCS(60)
      DIMENSION VMAX2(6,085)                                            0005
      DIMENSION XK3(6,6,085)                                            0005
      DIMENSION NPAP(2)
      COMMON/IPT/INPAP,IPAP
      COMMON/INT75/NV
      COMMON/PNOS/PN(85)
      COMMON/IDERV/IRUPSW(085),IPENSW(085)                              0005
      COMMON /BLANK1/ XX(50),XY(50),XZ(50),XL(50),XM(50),               0006
     1 XN(50),DPX(50),DPY(50),DPZ(50),DPL(50),DPM(50),DPN(50),PIN(50),  0007
     2 GIN(50),RIN(50),XI1(50),XI2(50),XI3(50),XI4(50),XI5(50),XI6(50), 0008
     3 XXK(085),XYK(085),XZK(085),XLK(085),XMK(085),XNK(085),XXJ(085),  0009
     4 XYJ(085),XZJ(085),XLJ(085),XMJ(085),XNJ(085),                    0010
     5   DELI(50),POLD(50),QOLD(50),ROLD(50),UOLD(50),VOLD(50),         0011
     6 WOLD(50),XOLD(50),YOLD(50),ZOLD(50),PINO(50),QINO(50),RINO(50),  0012
     7 OXIJ(085),OYIJ(085),OZIJ(085),PHIOLD(50),THEOLD(50),PSIOLD(50),  0013
     8 TPEN(085),TRUPT(085),DTHALF                                      0014
      COMMON /IBLANK/ IJKK,KPEN,KRUPT,IPEN(085),IRUPT(085),JRUPT(085)   0015
      COMMON/MAINCF/     IPRINT,ITPLOT,IBS(50,3)                        0016
      COMMON/COMALL/ C(6,085),P(50),Q(50),R(50),U(50),V(50),W(50),X(50),0017
     1 Y(50),Z(50),AI(9),AJ(9),XKREF(6,85),SC(50,3),XC(6),
     A XK(3060),XI(50),
     2YI(50),ZI(50),XYI(50),XZI(50),YZI(50),AIJ(9),BIJ(450),DIJ(765),
     3 DRI(085),OAI(450),VEE(510),WGT(50),PHI(50),THETA(50),PSI(50),    0020
     4 PDOT(50),QDOT(50),RDOT(50),UDOT(50),VDOT(50),WDOT(50),XDOT(50),  0021
     5 YDOT(50),ZDOT(50),PHIDOT(50),THEDOT(50),PSIDOT(50),TIME,DELTAT,  0022
     6XACC(50),YACC(50),ZACC(50),AITAJ(9),AIDOT(9),FMBAR(6,85),
     A DELFMO(3060),
```

```
7 PHIIJ(085),THEIJ(085),PSIIJ(085),SUMDF(6,085),TITLE(20),          0024
8 XLBAR(50,3),FSPBAR(50,3),VEEDOT(3,3),DX(50),DY(50),DZ(50),        0025
8 DPIN(50),DQIN(50),DRIN(50),                                       0026
8            SEIJ(085),DEIJ(085),CEIK(50,3), TMAX                   0027
 COMMON / ICOMAL/ MAXNM,MAXIGS,MAXTBL,INDP,                         0028
A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085),  0029
B N(510),NM(50,3),ISP(50,3),IJPR(085),IDPLOT(010)                   0030
 COMMON/DP74/XMU(50,3),XKE(50,3),SI(50,3),SA(50,3),SB(50,3),
2 SF(50,3),FSPOI(50,3),FSPOF(50,3)                                  0033
 COMMON/DERIN/HEX(50),HEY(50),HEZ(50),ALIFT(50),VMAX(510)           0034
1 ,PHIDP(50),THEDP(50),PSIDP(50),PHIPR,THEPR,PSIPR                  0035
 COMMON/DERIN1/XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR                  0036
 COMMON /IN74/ ZG,XGDOT,ZGDOT,YGDOT,PPR,QPR,RPR                     0037
 COMMON/INTG/ INBUF(50),II(121),KK(121),IR(121),JR(121),            0038
1            IQ(121),JQ(121),LQ(121),NPQ(121),IKCT                  0039
 COMMON/ COMPLY/PROP(20,3),PTIM,TMEL(085),CKPT(085,4,8),EALW(085,4)0039
 COMMON/ ICOPLY/ NE(085),NDS,NID(085),NCP(085),NS,L3                0039
 COMMON/ PYLD/SIGB(085,4),TXY(085,4),TXZ(085,4),SU(085,4),SV(085,4)0039
 COMMON/IPYLD/YIELD(085,4),PLAST(085,4)
 COMMON/LINES/XKS(1200),XKR(1200),NLSFLG(510),CHUG(120)
 COMMON/ICSYM/NSYM(20),ISDF(40)
 COMMON/SDFCO/SDF(85)
 COMMON/DLAR/PTHO(85),YAWO(85)
 COMMON/PLOT1/ NOPLOT,NMPT(5,40),ISCALE(5),KTYPE(5),NPTC,KPLT
 COMMON/ STITLE/ SUBI(5,20),PLTT
 EQUIVALENCE (NPLT(1),NOPLOT),(SSTIT(1),SUBI(1,1))
 EQUIVALENCE(DLG(1),PTHO(1))
 EQUIVALENCE(IPLY(1),YIELD(1,1))
 EQUIVALENCE (ICCS(1),NSYM(1))                                      0040
 EQUIVALENCE (VARC(1),DELTMN)
 EQUIVALENCE (BLK1(1),XX(1)),(IBLK(1),IJKK),(XMA(1),IPRINT),        0041
1(COML(1),C(1,1)),(ICOM(1),MAXNM),(D74(1),XMU(1)),(DER(1),HEX(1)),
2  (DER1(1),XNBAR),(XI74(1),ZG),(ING(1),INBUF(1))                   0043
3  ,( IDER(1),IRUPSW(1))                                            0043
 EQUIVALENCE (VMAX(1),VMAX2(1))                                     0043
 EQUIVALENCE (XK(1),XK3(1,1,1))                                     0043
 EQUIVALENCE (COM(1),PROP(1,1)),(ICO(1),NE(1))                      0043
 EQUIVALENCE (PLY(1),SIGB(1,1))                                     0043
 EQUIVALENCE (NPAP(1),INPAP)
 NAMELIST/CHANGE/IPRINT,ITPLOT,IBS,TIME,DELTAT,TITLE,
1XLBAR,FSPBAR,TMAX,INDP,IPLC,IPLOT,IJPR,IPPLOT,XMU,XKE,
2SI,SA,SB,SF,FSPOI,FSPOF,ALIFT,VMAX,XNBAR,XPBAR,YNBAR,XZI,
3YPBAR,ZNBAR,ZPBAR,EEQ
H ,XKS,XKI,XKR,XK3,NFSFLG,CHUG,VMAX2,PTIM,PROP,TMEL,CKPT,EALW,      0061
INCS,NE,NID,NCP,NS,NSYM                                             0061
J,ISDF,SDF,INPAP
X ,SUBI,PLTT,NOPLOT,NMPT,ISCALE,KTYPE,NPTC,KPLT
 PRINT 320, NCODE                                                   0062
 IF(NCODE.GT.9) GO TO 900                                           0063
10 READ(1) SAVTM,SAVDT                                              0064
 PRINT 310,SAVTM,SAVDT                                              0065
 IF(RSTIME.LT.SAVTM+SAVDT) GO TO 20                                 0066
 CALL FILMAN(1,1,1)                                                 0067
 XTEMP=1.                                                           0068
 PRINT 310,RSTIME,XTEMP                                             0069
 GO TO 10                                                           0070
20 READ(1) BLK1,IBLK,XMA,COML,ICOM,D74,DER,DER1,XI74,ING            0071
2,XKS,XKR,NLSFLG,CHUG,IDER,COM,ICO,PLY
3,ICCS,SDF,PN,VARC
4,IPLY,NV,DLG,NPAP
5 ,NPLT,SSTIT
 XTEMP=2.                                                           0073
 PRINT 310,RSTIME,XTEMP                                             0074
 CALL FILMAN(1,-1,1)                                                0075
 RSTIME=TIME                                                        0076
 CALL PRINT                                                         0077
 GO TO (1000,200,298,200),NCODE                                     0078
200 READ(5,CHANGE)
 IF(NCODE.LT.3) RETURN                                              0080
298 PRINT 299                                                       0080
```

```
299 FORMAT(2X,'***** THE FOLLOWING KR TABLES WERE NOT USED IN                0080
   1PREVIOUS RUNS *****',//)                                                  0080
300 READ 310,XICH,XNPQ,XIQ,XJQ,XLQ,XIJ
310 FORMAT(6E12.4)                                                            0082
    ICH=XICH                                                                  0083
    PRINT 320, ICH                                                            0084
    IF(ICH.LT.0) RETURN                                                       0085
    JK=(ICH+11)/10
    IQ(JK)=XIQ+.01                                                            0086
    JQ(JK)=XJQ+.01                                                            0086
    LQ(JK)=XLQ+.01                                                            0086
    IJ=XIJ+.01                                                                0086
    NLSFLG(6*(IJ-1)+LQ(JK))=JK                                                0086
    CHUG(JK)=XICH+1.                                                          0086
    NIJ=6*(IJ-1)+LQ(JK)                                                       0086
    PRINT 301,JK,NIJ,NLSFLG(NIJ)                                              0086
301 FORMAT(2X,'THIS IS RESTART',/2X,'JK=',I4,2X,'NIJ=',I4,2X,                 0086
   1'NLSFLG(NIJ)=',I4)                                                        0086
    NPQ(JK)=XNPQ+.01                                                          0087
    NP=XNPQ+.01                                                               0088
    READ 311,(XKR(ICH+JJ),KR(JJ),JJ=1,NP)
311 FORMAT(2E12.4)                                                            0089
    PRINT 315,IQ(JK),JQ(JK),LQ(JK),ICH                                        0090
315 FORMAT(1H0,'KR TABLE FOR I,J,L=',3I5,4X'TABLE ICH=',I4)                   0091
    PRINT 320,(JJ,XKR(ICH+JJ),KR(JJ),JJ=1,NP)                                 0092
320 FORMAT(1H ,I3,1P2E15.5)                                                   0093
    NPM1=NP-1                                                                 0094
    DO 350 JJ=1,NPM1                                                          0095
    SLOPE=KR(JJ)
    XKS(ICH+JJ)=SLOPE                                                         0097
350 CONTINUE
    GO TO 300                                                                 0101
900 IF(RSTIME.EQ.0.)GO TO 910                                                 0102
    XTEMP=3.                                                                  0103
    PRINT 310,RSTIME,XTEMP                                                    0104
    XTEMP=4.                                                                  0105
    PRINT 310,RSTIME,XTEMP                                                    0106
    XTEMP=5.                                                                  0107
    PRINT 310,RSTIME,XTEMP                                                    0108
910  XYZ=IPRINT                                                               0109
    PRINT 920                                                                 0109
920 FORMAT(//,'********** THE PREVIOUS TIME INCREMENT HAS BEEN PUT ON         0109
   1 TAPE******************'//)                                               0109
    XYZ=XPRS*DELTAT*XYZ                                                       0110
    PRINT 310, TIME,XYZ                                                       0111
    WRITE(1) TIME,XYZ                                                         0112
    PRINT 310, TIME,XYZ                                                       0113
     WRITE(1) BLK1,IBLK,XMA,CAML,ICOM,D74,DER,DER1,XI74,ING                   0114
   2,XKS,XKR,NLSFLG,CHUG,IDER,COM,ICO,PLY
   3,ICCS,SDF,PN,VARC
   4,IPLY,NV,DLG,NPAP
   5 ,NPLT,SSTIT
    XTEMP=6.                                                                  0116
    PRINT 310,RSTIME,XTEMP                                                    0117
    CALL ENDFIL(1,1)                                                          0118
    XTEMP=7.                                                                  0119
    PRINT 310,RSTIME,XTEMP                                                    0120
1000 RSTIME=RSTIME+XYZ                                                        0121
    RETURN                                                                    0122
    END                                                                       0123
!ASS (M:SO,LO)
!ASS (M:CI,DS,S79RIC;F)


!CUP CI,SO
      SUBROUTINE IC(ATMCK)                                                    0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/INT75/ NV                                                        0001
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```
C       MEMBER NAME S79RIC                                              0002
      DIMENSION XMPR(3),ABARPR(3,3),ANGDPR(3),DPR(3,3),AIDP(3,3),       0003
     1 AIC(3,3),ADPR(3,3),VJP(80,3),APR(3,3),VIP(3),XV(3)               0004
      COMMON /IN74/ ZG,XGDOT,ZGDOT,YGDOT,PPR,QPR,RPR                    0005
      COMMON/OP74/XMU(50,3),XKE(50,3),SI(50,3),SA(50,3),SB(50,3),
     2 SF(50,3),FSPOI(50,3),FSPAF(50,3)                                 0033
      COMMON/COMALL/ C(6,085),P(50),Q(50),R(50),U(50),V(50),W(50),X(50),0017
     1 Y(50),Z(50),AI(9),AJ(9),XKREF(6,85),SC(50,3),XC(6),
     A XK(3060),XI(50),
     2YI(50),ZI(50),XYI(50),XZI(50),YZI(50),AIJ(9),BIJ(450),DIJ(765),
     3 DRI(085),OAI(450),VEE(510),WGT(50),PHI(50),THETA(50),PSI(50),    0020
     4 PDOT(50),QDOT(50),RDOT(50),UDOT(50),VDOT(50),WDOT(50),XDOT(50),  0021
     5 YDOT(50),ZDOT(50),PHIDOT(50),THEDOT(50),PSIDOT(50),TIME,DELTAT,  0022
     6XACC(50),YACC(50),ZACC(50),AITAJ(9),AIDOT(9),FMBAR(6,85),
     A DELFMO(3060),
     7 PHIIJ(085),THEIJ(085),PSIIJ(085),SUMDF(6,085),TITLE(20),         0024
     8 XLBAR(50,3),FSPBAR(50,3),VEEDOT(3,3),DX(50),DY(50),DZ(50),       0025
     8 DPIN(50),DQIN(50),DRIN(50),                                      0026
     8           SEIJ(085),DEIJ(085),CEIK(50,3), TMAX                   0027
      COMMON / ICOMAL/ MAXNM,MAXIGS,MAXTBL,INDP,                        0020
     A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085), 0029
     B N(510),NM(50,3),ISP(50,3),IJPR(085),IDPLOT(010)                  0030
      COMMON/DERIN/HEX(50),HEY(50),HEZ(50),ALIFT(50),VMAX(510)          0034
     1 ,PHIDP(50),THEDP(50),PSIDP(50),PHIPR,THEPR,PSIPR                 0035
      EQUIVALENCE (PPR,XMPR(1)),(QPR,XMPR(2)),(RPR,XMPR(3)),            0025
     1  (PHIDPR,ANGDPR(1)),(THEDPR,ANGDPR(2)),(PSIDPR,ANGDPR(3))        0026
      COMMON/RPLA/CBAR(85),XDP(50),YDP(50),ZDP(50)
      SIN(G)= DSIN(G)                                                   0031
      COS(G)= DCOS(G)                                                   0032
      ARSIN(G)= DARSIN(G)                                               0033
      ATAN2(F,G)= DATAN2(F,G)                                           0034
      SQRT(G)= DSQRT(G)                                                 0035
      WTOT = 0.0                                                        0027
      DO 2010 I = 1,NM                                                  0028
 2010 WTOT = WTOT+WGT(I)                                                0029
      XGDP = 0.0                                                        0030
      YGDP = 0.0                                                        0031
      ZGDP = 0.0                                                        0032
      DO 2020 I = 1,NM                                                  0033
      XGDP = XGDP+WGT(I)*XDP(I)                                         0034
      YGDP = YGDP+WGT(I)*YDP(I)                                         0035
 2020 ZGDP = ZGDP+WGT(I)*ZDP(I)                                         0036
      XGDP = XGDP/WTOT                                                  0037
      YGDP = YGDP/WTOT                                                  0038
      ZGDP = ZGDP/WTOT                                                  0039
      IF(ATMCK.NE.0.) GO TO 5
      XPOL=0.                                                           0040
      YPOL=0.
      ZPOL=0.
      DO 2021 I=1,NM                                                    0041
      RX=(XDP(I)-XGDP)**2
      RY=(YDP(I)-YGDP)**2
      RZ=(ZDP(I)-ZGDP)**2
      XPOL=XPOL+WGT(I)*(RY+RZ)/386.+XI(I)
      YPOL=YPOL+WGT(I)*(RX+RZ)/386.+YI(I)
 2021 ZPOL=ZPOL+WGT(I)*(RX+RY)/386.+ZI(I)
      PRINT 2302,XGDP,YGDP,ZGDP,WTOT,XPOL,YPOL,ZPOL
 2302 FORMAT(//2X,'MODEL PROPERTIES'/5X,'CENTER OF GRAVITY-INCHES'/
     1 10X,'XCG=',E12.6,5X,'YCG=',E12.6,5X,'ZCG=',E12.6/5X,
     2'WEIGHT-LB'/10X,E12.6/5X,'INERTIAS LB-IN-SEC**2'/
     3 2X,'IX=',E12.6,5X,'IY=',E12.6,5X,'IZ=',E12.6)
    5 CONTINUE
C APRIME AND ABARPRIME (3)                                              0047
      CALL EULER(APR,PHIPR,THEPR,PSIPR)                                 0048
      S1 = SIN(PHIPR)                                                   0049
      C1 = COS(PHIPR)                                                   0050
      S2 = SIN(THEPR)                                                   0051
      C2 = COS(THEPR)                                                   0052
C NOW ABARPRIME (4)                                                     0053
      ABARPR(1,1) = 1.0                                                 0054
```

```
      ABARPR(2,1) = 0.0
      ABARPR(3,1) = 0.0
      ABARPR(1,2) = S1*S2/C2
      ABARPR(2,2) = C1
      ABARPR(3,2) = S1/C2
      ABARPR(1,3) = C1*S2/C2
      ABARPR(2,3) = -S1
      ABARPR(3,3) = C1/C2
C ANGLE DOT PRIMES (6)
      CALL MATVEC(ABARPR,XMPR,ANGDPR,0)
C D PRIME (7)
      DPR(1,1) = 0.0
      DPR(1,2) = THEDPR*S1-PSIDPR*C1*C2
      DPR(1,3) = THEDPR*C1+PSIDPR*S1*C2
      DPR(2,1) = -DPR(1,2)
      DPR(2,2) = 0.0
      DPR(2,3) = -PHIDPR+PSIDPR*S2
      DPR(3,1) = -DPR(1,3)
      DPR(3,2) = -DPR(2,3)
      DPR(3,3) = 0.0
C A DOT PRIME (8)
      CALL MATMUL(APR,DPR,ADPR)
      ZCMAX = 0.0
C LOOP A
      DO 2040 I = 1,NM
C AI DOUBLE PRIME (9)
      CALL EULER(AIDP,PHIDP(I),THEDP(I),PSIDP(I))
C AI (10)
      CALL MATMUL(APR,AIDP,AIC)
      THETA(I) = -ARSIN(AIC(3,1))
      CT = 1.0/COS(THETA(I))
      PHI(I) = ARSIN(AIC(3,2)*CT)
      PSI(I) = ARSIN(AIC(2,1)*CT)
C (12)
      VJP(I,1) = XGDP-XDP(I)
      VJP(I,2) = YGDP-YDP(I)
      VJP(I,3) = ZGDP-ZDP(I)
C LOOP B
      DO 2050 K = 1,3
      IF(ISP(I,K)) 2060,2050,2040
 2060 VC = AIC(3,K)*XLBAR(I,K)
      DO 2070 L = 1,3
 2070 VC = VC+APR(3,L)*VJP(I,L)
      IF(VC-ZCMAX) 2050,2050,2080
 2080 ZCMAX = VC
 2050 CONTINUE
      VIP(1) = VJP(I,1)
      VIP(2) = VJP(I,2)
      VIP(3) = VJP(I,3)
C (15)
      CALL MATVEC(ADPR,VIP,XV,0)
      XV(1) = XV(1)+XGDOT
      XV(2) = XV(2)+YGDOT
      XV(3) = XV(3)+ZGDOT
C---------SPECIAL COND FOR SOAC ON CARDS 00  INSERTED BY ED WIDMAYER ON
C                                  6-6-74
C
C THIS SECTION ZEROES OUT INIAL LINEAR VELOCITY COMP FOR 1ST NV MASSES
      IF(I.GT.NV) GO TO 2193
      PRINT 3000,I
 3000 FORMAT(1X,'C**********'/1X,'MASS= ',I4)
      XV(1)=0.
      XV(2)=0.
      XV(3)=0.
C*********************************************************************
 2193 XDOT(I)=XV(1)
      YDOT(I) = XV(2)
      ZDOT(I) = XV(3)
C (16)
      CALL MATVEC(AIC,XV,VIP,1)
```

```
      U(I) = VIP(1)
      V(I) = VIP(2)
      W(I) = VIP(3)
C (17)
      CALL MATVEC(AIDP,XMPR,VIP,1)
      P(I) = VIP(1)
      Q(I) = VIP(2)
      R(I) = VIP(3)
C THIS TEST SETS ANGULAR VELOCITIES OF 1ST NV MASSES TO '0'
      IF(I.GT.NV) GO TO 3010
       P(I)=0.
       Q(I)=0.
       R(I)=0.
C AIBAR (18)
 3010 S1 = SIN(PHI(I))
      C1 = COS(PHI(I))
      S2 = SIN(THETA(I))
      C2 = COS(THETA(I))
      ABARPR(1,2) = S1*S2/C2
      ABARPR(2,2) = C1
      ABARPR(3,2) = S1/C2
      ABARPR(1,3) = C1*S2/C2
      ABARPR(2,3) = -S1
      ABARPR(3,3) = C1/C2
C (19)
      CALL MATVEC(ABARPR,VIP,XV,0)
 2303 PHIDOT(I)=XV(1)
      THEDOT(I) = XV(2)
      PSIDOT(I) = XV(3)
C END LOOP C
 2040 CONTINUE
      IF(ZG.EQ.0.) ZG=-ZCMAX-.001D0
C IF WE GET HERE WE COMPUTE NEW THETA(I,J) AND PSI(I,J)
C     BEAM COMPONENTS IN AIRFRAME AXES
      PI = 3.14159265358979324D0
      PI2 = .5D0*PI
      DO 2200 IJ = 1,IGS
      I = IG(IJ)
      J = JG(IJ)
      XIJP = VJP(J,1)-VJP(I,1)
      YIJP = VJP(J,2)-VJP(I,2)
      ZIJP = VJP(J,3)-VJP(I,3)
C*****************************************************************************
C     IF ITH MASS AXES NOT PARALLEL TO AIRFRAME TRANSFORM COMPONENTS TO MASS
      IF(PSIDP(I).EQ.0.0.AND.THEDP(I).EQ.0.0.AND.PHIDP(I).EQ.0.0)
     1 GO TO 200
      S1=SIN(PHIDP(I))
      C1=COS(PHIDP(I))
      S2=SIN(THEDP(I))
      C2=COS(THEDP(I))
      S3=SIN(PSIDP(I))
      C3=COS(PSIDP(I))
      AI(1)=C2*C3
      AI(2)=C2*S3
      AI(3)=-S2
      AI(4)=-C1*S3+S1*S2*C3
      AI(5)=C1*C3+S1*S2*S3
      AI(6)=S1*C2
      AI(7)=S1*S3+C1*S2*C3
      AI(8)=-S1*C3+C1*S2*S3
      AI(9)=C1*C2
C     TRANSFORM ELEMENT TO MASS AXES
      XNX=AI(1)*XIJP+AI(2)*YIJP+AI(3)*ZIJP
      YNY=AI(4)*XIJP+AI(5)*YIJP+AI(6)*ZIJP
      ZNZ=AI(7)*XIJP+AI(8)*YIJP+AI(9)*ZIJP
      XIJP=XNX
      YIJP=YNY
      ZIJP=ZNZ
  200 IF(YIJP.NE.0.) GO TO 2140
 2130 IF(XIJP) 2180,2170,2180
```

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```
 2180 PSIIJ(IJ) = 0.0                                                  0123
      THEIJ(IJ) = -ATAN2(ZIJP,XIJP)                                    0124
      GO TO 2200                                                       0125
 2170 PSIIJ(IJ) = 0.0                                                  0126
      THEIJ(IJ) = -PI2                                                 0127
      IF(ZIJP) 2160,2200,2200                                          0128
 2160 THEIJ(IJ) = PI2                                                  0129
      GO TO 2200                                                       0130
 2140 PSIIJ(IJ) = ATAN2(YIJP,XIJP)                                     0131
      THEIJ(IJ) = -ATAN2(ZIJP,SQRT(XIJP*XIJP+YIJP*YIJP))               0132
 2200 CONTINUE                                                         0133
      DO 2090 I=1,NM
      VIP(1)= VJP(I,1)
      VIP(2)= VJP(I,2)
      VIP(3)= VJP(I,3)
      CALL MATVEC(APR,VIP,XV,0)                                        0140
      XV(3) = XV(3)+ZG                                                 0141
      X(I) = XV(1)                                                     0142
      Y(I) = XV(2)                                                     0143
      Z(I) = XV(3)                                                     0144
 2090 CONTINUE                                                         0190
      IF(ATMCK.GT.0.) RETURN                                           0190
      PRINT 2301                                                       0191
 2301 FORMAT(1H0,'IJ,THEIJ(IJ),PSIIJ(IJ)' )                            0192
      PRINT 2300,(IJ,THEIJ(IJ),PSIIJ(IJ),IJ=1,IGS)                     0193
 2300 FORMAT (1H ,I5,1P2E15.5)                                         0194
      RETURN                                                           0195
      END                                                              0196
!ASS (M:SO,LO)
!ASS (M:CI,DS,S79RPY;F)


!CUP CI,SO
      SUBROUTINE PLAYLD                                                0001
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*4 BLANK,ASTRIC,YIELD,PLAST
C     MEMBER NAME S79RPYLD                                             0002
C                                                                      0003
C     THIS ROUTINE CALAULATES STRESSES AND DETERMINES YIELD STATE      0004
      COMMON/ COMPLY/PROP(20,3),PTIM,TMEL(085),CKPT(085,4,8),EALW(085,4)0039
C                                                                      0006
      COMMON/ ICOPLY/ NE(085),NDS,NID(085),NCP(085),NS,L3              0039
C                                                                      0008
      COMMON/ PYLD/SIGB(085,4),TXY(085,4),TXZ(085,4),SU(085,4),SV(085,4)0039
      COMMON/IPYLD/YIELD(085,4),PLAST(085,4)
      COMMON/ ICOMAL/ MAXNM,MAXIGS,MAXTBL,INDP,                        0011
     A NM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(010),IG(085),JG(085), 0029
     B N(510),NN(50,3),ISP(50,3),IJPR(085),IDPLOT(010)                 0030
      COMMON/COMALL/ C(6,085),P(50),Q(50),R(50),U(50),V(50),W(50),X(50),0017
     1 Y(50),Z(50),AI(9),AJ(9),XKREF(6,85),SC(50,3),XC(6),
     A XK(3060),XI(50),
     2YI(50),ZI(50),XYI(50),XZI(50),YZI(50),AIJ(9),BIJ(450),DIJ(765),
     3 DHI(085),OAI(450),VEE(510),WGT(50),PHI(50),THETA(50),PSI(50),   0020
     4 PDOT(50),QDOT(50),RDOT(50),UDOT(50),VDOT(50),WDOT(50),XDOT(50), 0021
     5 YDOT(50),ZDOT(50),PHIDOT(50),THEDOT(50),PSIDOT(50),TIME,DELTAT, 0022
     6XACC(50),YACC(50),ZACC(50),AITAJ(9),AIDOT(9),FMBAR(6,85),
     A DELFMO(3060),
     7 PHIIJ(085),THEIJ(085),PSIIJ(085),SUMDF(6,085),TITLE(20),        0024
     8 XLBAR(50,3),FSPBAR(50,3),VEEDOT(3,3),DX(50),DY(50),DZ(50),      0025
     8 DPIN(50),DQIN(50),DRIN(50),                                     0026
     8         SEIJ(085),DEIJ(085),CEIK(50,3), TMAX                    0027
      COMMON /BLANK1/ XX(50),XY(50),XZ(50),XL(50),XM(50),              0006
     1 XN(50),DPX(50),DPY(50),DPZ(50),DPL(50),DPM(50),DPN(50),PIN(50), 0007
     2 GIN(50),RIN(50),XI1(50),XI2(50),XI3(50),XI4(50),XI5(50),XI6(50), 0008
     3 XXK(085),XYK(085),XZK(085),XLK(085),XMK(085),XNK(085),XXJ(085), 0009
     4 XYJ(085),XZJ(085),XLJ(085),XMJ(085),XNJ(085),                   0010
```

```
5   DELI(50),POLD(50),WOLD(50),ROLD(50),UOLD(50),VOLD(50),
6 WOLD(50),XOLD(50),YOLD(50),ZOLD(50),PINO(50),QINO(50),RINO(50),
7 OXIJ(085),OYIJ(085),OZIJ(085),PHIOLD(50),THEOLD(50),PSIOLD(50),
8 TPEN(085),TRUPT(085),DTHALF
  DIMENSION SIGA(85)
  DATA ASTRIC,BLANK/4H   *,4H    /
  SQRT(G)= DSQRT(G)
  DO 100 K=1,NS
  IF(TIME.LE.TMEL(K)) GO TO 100
  M=NE(K)
C     CALCULATION OF AXIAL STRESS
  SIGA(K)=SUMDF(1,M)/PROP(NID(K),1)
  MM=NCP(K)
  DO 110 L=1,MM
C     CALCULATION OF BENDING STRESSES
  SIGB(K,L)=(CKPT(K,L,1)*SUMDF(5,M)/PROP(NID(K),2))+(CKPT(K,L,2)
* *SUMDF(6,M)
1 /PROP(NID(K),3))
  TXY(K,L)=(CKPT(K,L,3)*SUMDF(2,M)/PROP(NID(K),2))+(CKPT(K,L,5)
* *SUMDF(3,M)
1 /PROP(NID(K),3))
  TXZ(K,L)=(CKPT(K,L,4)*SUMDF(2,M)/PROP(NID(K),2))+(CKPT(K,L,6)
* *SUMDF(3,M)
1 /PROP(NID(K),3))
C     CALCULATION OF TOTAL STRESSES
  SIGB(K,L)=SIGB(K,L)+SIGA(K)
  TXY(K,L)=TXY(K,L)+CKPT(K,L,7)*SUMDF(4,M)
  TXZ(K,L)=TXZ(K,L)+CKPT(K,L,8)*SUMDF(4,M)
C     CALCULATION OF PRINCIPAL STRESSES
  RAT=SQRT(SIGB(K,L)*SIGB(K,L)+4.*(TXY(K,L)*TXY(K,L)+TXZ(K,L)*
1 TXZ(K,L)))
  SU(K,L)=.5*(SIGB(K,L)-RAT)
  SV(K,L)=.5*(SIGB(K,L)+RAT)
  VONM=(SU(K,L)*SU(K,L)-SU(K,L)*SV(K,L)+SV(K,L)*SV(K,L))/
1 (EALW(K,L)*EALW(K,L))
  IF(VONM.LT.1.0) GO TO 110
  YIELD(K,L)=ASTRIC
  PLAST(K,L)=ASTRIC
110 CONTINUE
100 CONTINUE
  RETURN
  END
!ASS (M:SO,LO)
!ASS (M:CI,D5,S79RDE:F)
```

APPENDIX F
CH-47A CRASH TEST SIMULATION, S7900, RUN 1013JD

INPUT DATA

```
CH-47A POST TEST MODEL   36 NODES  V=340,0,522   DEG=0,-8.7,0                    LOAD MODULE S79TEST CREATED 6-17-76

**** CONTROL DATA ****
CODE NO.     RSTIME       XPRS        XNCASE       XPLOT        ATMCK
 .1000E 01   .0000E 00   .1000E 01   .0000E 00   .0000E 00   .1000E 01
MASSES= 37DP/DT=100DT=  .10000E-06TMAX=  .18000E 00INPAP=  0

LONGITUDINAL SYMMETRY AT MASSES NSYM(JK)=
   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,

BEAMS IN COMPRESSION OR TENSION ISDF(IGS)=
  -5,  -6, -10, -14, -19, -23, -26, -31, -34, -35, -40, -41, -44, -48, -50, -53, -62, -65, -71, -76,
   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
INTEGRATION CONTROLS AND ERROR TOLERANCE EEQ=  .10000E-03 EER=  .10000E-02 EROT=  .10000E-02

****INITIAL CONDITIONS****
THE FIRST NV MASSES HAVE ZERO INITIAL VELOCITIES
   NV=   0
XGDOT =  3.40000E 02  YGDOT =   .00000E 00  ZGDOT =  5.22000E 02
   P' =   .00000E 00     Q' =  1.14500E-01     R' =   .00000E 00
 PHI' =   .00000E 00 THETA' = -1.51800E-01   PSI' =   .00000E 00      ZG =   .00000E 00

**** BULK DATA ****

WEIGHTS
   1      1.21200E 03
   2      1.71800E 03
   3      2.47800E 03
   4      1.75000E 02
   5      1.75000E 02
   6      2.18800E 02
   7      2.18800E 02
   8      1.08150E 03
   9      1.61000E 02
  10      1.60100E 03
  11      1.10550E 03
  12      1.61000E 02
  13      2.18800E 02
  14      2.05550E 02
  15      1.54400E 02
  16      1.48940E 03
  17      1.88240E 03
  18      1.43750E 03
  19      1.54400E 02
  20      5.74750E 02
  21      3.03900E 02
```

22	3.70000E 02
23	1.96000E 02
24	1.30660E 03
25	3.70000E 02
26	1.96000E 02
27	3.03900E 02
28	7.73000E 02
29	7.73000E 02
30	9.70000E 01
31	3.15000E 02
32	4.74000E 02
33	1.19200E 03
34	1.39600E 03
35	2.12000E 02
36	2.12000E 02
37	9.70000E 01

INERTIAS

I,IX(I),IY(I),IZ(I),IXY(I),IYZ(I),IXZ(I)

1	4.08000E 02	3.97000E 02	7.62000E 02	.00000E 00	.00000E 00	.00000E 00
2	5.19500E 03	6.27100E 03	6.13400E 03	.00000E 00	.00000E 00	.00000E 00
3	6.37900E 03	7.67900E 03	7.52900E 03	.00000E 00	.00000E 00	.00000E 00
4	1.13000E 01	1.44800E 02	5.00000E 01	.00000E 00	.00000E 00	.00000E 00
5	1.13000E 01	1.44800E 02	5.00000E 01	.00000E 00	.00000E 00	.00000E 00
6	1.70400E 02	8.38800E 02	9.75600E 02	.00000E 00	.00000E 00	.00000E 00
7	1.70400E 02	8.38800E 02	9.75600E 02	.00000E 00	.00000E 00	.00000E 00
8	7.35700E 02	1.88580E 03	1.92020E 03	.00000E 00	.00000E 00	.00000E 00
9	1.50000E 02	1.56000E 02	2.22000E 01	.00000E 00	.00000E 00	.00000E 00
10	4.43900E 02	1.45780E 03	1.60610E 03	.00000E 00	.00000E 00	.00000E 00
11	7.35700E 02	1.88580E 03	1.92020E 03	.00000E 00	.00000E 00	.00000E 00
12	1.50000E 02	1.56000E 02	2.22000E 01	.00000E 00	.00000E 00	.00000E 00
13	1.70400E 02	8.38800E 02	9.75600E 02	.00000E 00	.00000E 00	.00000E 00
14	1.58600E 02	5.19600E 02	6.08400E 02	.00000E 00	.00000E 00	.00000E 00
15	1.53600E 02	5.19600E 02	6.08400E 02	.00000E 00	.00000E 00	.00000E 00
16	6.39700E 02	2.01830E 03	1.74130E 03	.00000E 00	.00000E 00	.00000E 00
17	9.10700E 02	1.99140E 03	2.02980E 03	.00000E 00	.00000E 00	.00000E 00
18	6.39700E 02	2.01830E 03	1.74130E 03	.00000E 00	.00000E 00	.00000E 00
19	1.53600E 02	5.19600E 02	6.08400E 02	.00000E 00	.00000E 00	.00000E 00
20	1.36180E 03	1.38000E 03	1.61880E 03	.00000E 00	.00000E 00	.00000E 00
21	1.33680E 03	1.38000E 03	1.61880E 03	.00000E 00	.00000E 00	.00000E 00
22	2.14700E 03	1.85000E 03	2.09050E 03	.00000E 00	.00000E 00	.00000E 00
23	1.37600E 02	2.77200E 02	1.83600E 02	.00000E 00	.00000E 00	.00000E 00
24	1.72050E 03	1.48240E 03	1.67510E 03	.00000E 00	.00000E 00	.00000E 00
25	2.14700E 03	1.85000E 03	2.09050E 03	.00000E 00	.00000E 00	.00000E 00
26	1.37600E 02	2.77200E 02	1.83600E 02	.00000E 00	.00000E 00	.00000E 00
27	1.33680E 03	1.38000E 03	1.61880E 03	.00000E 00	.00000E 00	.00000E 00
28	1.21200E 02	1.10400E 03	1.10400E 03	.00000E 00	.00000E 00	.00000E 00
29	1.21200E 02	1.10400E 03	1.10400E 03	.00000E 00	.00000E 00	.00000E 00
30	8.94000E 01	9.32000E 01	1.34000E 01	.00000E 00	.00000E 00	.00000E 00
31	2.93520E 03	2.16120E 03	2.16120E 03	.00000E 00	.00000E 00	.00000E 00
32	4.41600E 03	3.25200E 03	3.25200E 03	.00000E 00	.00000E 00	.00000E 00
33	1.38960E 03	5.96400E 02	2.05200E 02	.00000E 00	.00000E 00	.00000E 00
34	1.38960E 03	5.96400E 02	6.53000E 01	.00000E 00	.00000E 00	.00000E 00
35	1.37000E 02	1.75000E 02	6.07000E 01	.00000E 00	.00000E 00	.00000E 00
36	1.37000E 02	1.75000E 02	6.07000E 01	.00000E 00	.00000E 00	.00000E 00
37	8.94000E 01	9.32000E 01	1.34000E 01	.00000E 00	.00000E 00	.00000E 00

COORDINATES

I,X''(I),Y''(I),Z''(I)

1	8.60000E 01	.00000E 00	9.98800E 01
2	9.23400E 01	.00000E 00	6.62700E 01
3	9.50000E 01	.00000E 00	-3.00000E 01
4	7.51500E 01	-2.10000E 01	-1.70000E 01
5	7.51500E 01	2.10000E 01	-1.70000E 01
6	2.40000E 02	.00000E 00	5.54000E 01
7	2.40000E 02	-4.65000E 01	4.66000E 01
8	2.40000E 02	-4.88000E 01	-3.60000E 01
9	2.45000E 02	-6.30000E 01	-4.56500E 01
10	2.40000E 02	.00000E 00	-3.60000E 01
11	2.40000E 02	4.88000E 01	-3.60000E 01
12	2.45000E 02	6.30000E 01	-4.56500E 01
13	2.40000E 02	4.65000E 01	4.66000E 01
14	3.60000E 02	.00000E 00	5.54000E 01
15	3.60000E 02	-4.65000E 01	4.66000E 01
16	3.60000E 02	-4.88000E 01	-3.60000E 01
17	3.60000E 02	.00000E 00	-3.60000E 01
18	3.60000E 02	4.88000E 01	-3.60000E 01
19	3.60000E 02	4.65000E 01	4.66000E 01
20	4.82000E 02	.00000E 00	5.54000E 01
21	4.82000E 02	-4.65000E 01	4.66000E 01
22	4.82000E 02	-4.88000E 01	-3.60000E 01
23	5.09000E 02	-6.30000E 01	-4.03000E 01
24	4.82000E 02	.00000E 00	-3.60000E 01
25	4.82000E 02	4.88000E 01	-3.60000E 01
26	5.09000E 02	6.30000E 01	-4.08000E 01
27	4.82000E 02	4.65000E 01	4.66000E 01
28	5.04920E 02	-4.84500E 01	6.62400E 01
29	5.04920E 02	4.84500E 01	6.62400E 01
30	2.40000E 02	-4.88000E 01	-5.69720E 01
31	5.76000E 02	.00000E 00	1.00000E 02
32	5.76000E 02	.00000E 00	8.50000E 00
33	5.58100E 02	.00000E 00	5.95000E 01
34	5.52620E 02	.00000E 00	1.55530E 02
35	7.51500E 01	-2.10000E 01	5.50000E 00
36	7.51500E 01	2.10000E 01	5.50000E 00
37	2.40000E 02	4.88000E 01	-5.69720E 01

THERE ARE 0 I'S HAVING NON-ZERO HE OR PHI'',THETA'',PSI''

THERE ARE 0 I'S HAVING NON-ZERO LC'S

SPRING DATA

I,K,LBAR(I,K),MU(I,K),KE(I,K)

3	3	1.02500E 01	3.00000E-01	2.00000E 05
4	3	2.30000E 01	3.00000E-01	1.00000E 04
5	3	2.30000E 01	3.00000E-01	1.00000E 04
8	3	7.00000E 00	3.00000E-01	1.56750E 05
9	3	3.11800E 01	5.00000E-01	1.05320E 04
10	3	7.00000E 00	3.00000E-01	1.56750E 05
11	3	7.00000E 00	3.00000E-01	1.56750E 05
12	3	3.11800E 01	5.00000E-01	1.05320E 04
16	3	7.00000E 00	3.00000E-01	1.42500E 05

17	3	7.00000E 00	3.00000E-01	1.42500E 05
18	3	7.00000E 00	3.00000E-01	1.42500E 05
22	3	7.00000E 00	3.00000E-01	1.14000E 05
23	3	2.76800E 01	5.00000E-01	6.00000E 06
24	3	7.00000E 00	3.00000E-01	1.14000E 05
25	3	7.00000E 00	3.00000E-01	1.14000E 05
26	3	2.76800E 01	5.00000E-01	6.00000E 06
30	3	2.07860E 01	.00000E 00	8.00000E 04
37	3	2.07860E 01	.00000E 00	8.00000E 04

I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPBI(I,K),FSPBF(I,K)

3	3	2.16000E-01	7.23000E 00	7.24000E 00	7.25000E 00	4.53000E 04	4.93000E 04
4	3	1.25000E 00	2.10000E 01	2.10100E 01	2.10200E 01	1.25000E 04	1.27000E 04
5	3	1.25000E 00	2.10000E 01	2.10100E 01	2.10200E 01	1.25000E 04	1.27000E 04
8	3	7.90000E-02	1.00000E-01	5.90000E 00	6.00000E 00	1.65083E 05	1.65083E 04
9	3	2.50000E-01	1.40000E 01	2.20000E 01	2.20010E 01	2.63300E 03	8.69200E 04
10	3	7.90000E-02	1.00000E-01	5.90000E 00	6.00000E 00	1.65083E 05	1.65083E 04
11	3	7.90000E-02	1.00000E-01	5.90000E 00	6.00000E 00	1.65083E 05	1.65083E 04
12	3	2.50000E-01	1.40000E 01	2.20000E 01	2.20010E 01	2.63300E 03	8.69200E 04
16	3	7.90000E-02	1.00000E-01	5.90000E 00	6.00000E 00	1.50075E 05	1.50075E 04
17	3	7.90000E-02	1.00000E-01	5.90000E 00	6.00000E 00	1.50075E 05	1.50075E 04
18	3	7.90000E-02	1.00000E-01	5.90000E 00	6.00000E 00	1.50075E 05	1.50075E 04
22	3	7.90000E-02	1.00000E-01	5.90000E 00	6.00000E 00	1.20060E 05	1.20060E 04
23	3	1.50000E 00	5.00000E 00	7.15000E 00	1.75000E 01	2.00000E 04	1.12000E 05
24	3	7.90000E-02	1.00000E-01	5.90000E 00	6.00000E 00	1.20060E 05	1.20060E 04
25	3	7.90000E-02	1.00000E-01	5.90000E 00	6.00000E 00	1.20060E 05	1.20060E 04
26	3	1.50000E 00	5.00000E 00	7.15000E 00	1.75000E 01	2.00000E 04	1.12000E 05
30	3	1.00000E 00	1.01000E 00	1.02000E 00	1.03000E 00	8.00000E 04	8.24000E 04
37	3	1.00000E 00	1.01000E 00	1.02000E 00	1.03000E 00	8.00000E 04	8.24000E 04

IJ,I,J,PN,PHI(I,J),THETA(I,J),PSI(I,J) (INTERNAL BEAMS)

1	1	2	.00000E 00	.00000E 00	.00000E 00	.00000E 00
2	2	3	.00000E 00	.00000E 00	.00000E 00	.00000E 00
3	2	6	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
4	2	7	.00000E 00	.00000E 00	.00000E 00	.00000E 00
5	2	8	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
6	2	11	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
7	2	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00
8	3	4	.00000E 00	.00000E 00	.00000E 00	.00000E 00
9	3	5	.00000E 00	.00000E 00	.00000E 00	.00000E 00
10	3	7	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
11	3	8	.00000E 00	.00000E 00	.00000E 00	.00000E 00
12	3	10	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
13	3	11	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	3	13	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
15	6	7	.00000E 00	.00000E 00	.00000E 00	.00000E 00
16	6	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00
17	6	14	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
18	7	8	.00000E 00	.00000E 00	.00000E 00	.00000E 00
19	6	15	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	7	15	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	8	9	.00000E 00	.00000E 00	.00000E 00	.00000E 00
22	8	10	.00000E 00	.00000E 00	.00000E 00	.00000E 00
23	7	16	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
24	8	16	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	8	30	.00000E 00	.00000E 00	.00000E 00	.00000E 00
26	10	18	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
27	10	11	.00000E 00	.00000E 00	.00000E 00	.00000E 00

28	10	17	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
29	11	12	.00000E 00	.00000E 00	.00000E 00	.00000E 00
30	11	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00
31	10	16	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
32	11	18	.00000E 00	.00000E 00	.00000E 00	.00000E 00
33	11	37	.00000E 00	.00000E 00	.00000E 00	.00000E 00
34	13	18	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
35	6	19	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
36	13	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00
37	14	15	.00000E 00	.00000E 00	.00000E 00	.00000E 00
38	14	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00
39	14	20	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
40	14	21	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
41	14	27	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
42	15	16	.00000E 00	.00000E 00	.00000E 00	.00000E 00
43	15	21	.00000E 00	.00000E 00	.00000E 00	.00000E 00
44	15	22	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
45	16	17	.00000E 00	.00000E 00	.00000E 00	.00000E 00
46	16	22	.00000E 00	.00000E 00	.00000E 00	.00000E 00
47	17	18	.00000E 00	.00000E 00	.00000E 00	.00000E 00
48	17	22	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
49	17	24	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
50	17	25	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
51	18	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00
52	18	25	.00000E 00	.00000E 00	.00000E 00	.00000E 00
53	19	25	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
54	19	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00
55	20	21	.00000E 00	.00000E 00	.00000E 00	.00000E 00
56	20	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00
57	20	31	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
58	21	22	.00000E 00	.00000E 00	.00000E 00	.00000E 00
59	21	23	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
60	21	28	.00000E 00	.00000E 00	.00000E 00	.00000E 00
61	21	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00
62	21	32	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
63	22	23	.00000E 00	.00000E 00	.00000E 00	.00000E 00
64	22	24	.00000E 00	.00000E 00	.00000E 00	.00000E 00
65	22	31	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
66	22	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00
67	24	25	.00000E 00	.00000E 00	.00000E 00	.00000E 00
68	24	32	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
69	25	26	.00000E 00	.00000E 00	.00000E 00	.00000E 00
70	25	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00
71	25	31	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
72	25	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00
73	26	27	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
74	27	29	.00000E 00	.00000E 00	.00000E 00	.00000E 00
75	27	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00
76	27	32	1.00000E 00	.00000E 00	.00000E 00	.00000E 00
77	20	28	.00000E 00	.00000E 00	.00000E 00	.00000E 00
78	4	35	.00000E 00	.00000E 00	.00000E 00	.00000E 00
79	5	36	.00000E 00	.00000E 00	.00000E 00	.00000E 00
80	20	29	.00000E 00	.00000E 00	.00000E 00	.00000E 00
81	20	33	.00000E 00	.00000E 00	.00000E 00	.00000E 00
82	31	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00
83	31	33	.00000E 00	.00000E 00	.00000E 00	.00000E 00
84	31	34	.00000E 00	.00000E 00	.00000E 00	.00000E 00
85	33	34	.00000E 00	.00000E 00	.00000E 00	.00000E 00

IJ,I,K-MATRIX FOR INTERNAL BEAM IJ

1 2

2.64710E 06	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	3.02280E 05	.00000E 00	.00000E 00	.00000E 00	-5.13880E 06
.00000E 00	.00000E 00	3.02280E 05	.00000E 00	5.13880E 06	.00000E 00
.00000E 00	.00000E 00	.00000E 00	3.21180E 07	.00000E 00	.00000E 00
.00000E 00	.00000E 00	5.13880E 06	.00000E 00	1.28540E 08	.00000E 00
.00000E 00	-5.13880E 06	.00000E 00	.00000E 00	.00000E 00	1.28540E 08

2 3

2.13730E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	3.72120E 04	.00000E 00	.00000E 00	.00000E 00	-1.89780E 06
.00000E 00	.00000E 00	2.91680E 04	.00000E 00	1.48760E 06	.00000E 00
.00000E 00	.00000E 00	.00000E 00	1.19300E 07	.00000E 00	.00000E 00
.00000E 00	.00000E 00	1.48760E 06	.00000E 00	1.59630E 08	.00000E 00
.00000E 00	-1.89780E 06	.00000E 00	.00000E 00	.00000E 00	1.16750E 08

2 6

5.03510E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00

2 7

9.35280E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	2.71100E 01	.00000E 00	.00000E 00	.00000E 00	-2.30400E 03
.00000E 00	.00000E 00	3.14060E 03	.00000E 00	2.45040E 05	.00000E 00
.00000E 00	.00000E 00	.00000E 00	5.00000E 02	.00000E 00	.00000E 00
.00000E 00	.00000E 00	2.45040E 05	.00000E 00	2.61170E 07	.00000E 00
.00000E 00	-2.30400E 03	.00000E 00	.00000E 00	.00000E 00	2.61170E 05

2 8

5.92330E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00

2 11

5.92330E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00

2 13

9.35220E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	2.71100E 01	.00000E 00	.00000E 00	.00000E 00	-2.30400E 03
.00000E 00	.00000E 00	3.14000E 03	.00000E 00	2.45010E 05	.00000E 00
.00000E 00	.00000E 00	.00000E 00	5.00000E 02	.00000E 00	.00000E 00
.00000E 00	.00000E 00	2.45010E 05	.00000E 00	2.61160E 07	.00000E 00
.00000E 00	-2.30400E 03	.00000E 00	.00000E 00	.00000E 00	2.61170E 05

3 4

7.97690E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	2.03470E 05	.00000E 00	.00000E 00	.00000E 00	-3.52000E 06
.00000E 00	.00000E 00	1.78210E 05	.00000E 00	3.08290E 06	.00000E 00
.00000E 00	.00000E 00	.00000E 00	2.54740E 07	.00000E 00	.00000E 00
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.00000E 00	-3.52000E 06	.00000E 00	.00000E 00	.00000E 00	1.19570E 08

3 5

7.97490E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	2.03470E 05	.00000E 00	.00000E 00	.00000E 00	-3.52000E 06
.00000E 00	.00000E 00	1.78210E 05	.00000E 00	3.08290E 06	.00000E 00
.00000E 00	.00000E 00	.00000E 00	2.54740E 07	.00000E 00	.00000E 00
.00000E 00	.00000E 00	3.08290E 06	.00000E 00	9.49530E 07	.00000E 00
.00000E 00	-3.52000E 06	.00000E 00	.00000E 00	.00000E 00	1.19570E 08
3 7					
6.36440E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
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.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
3 8					
1.83250E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	9.95000E 01	.00000E 00	.00000E 00	.00000E 00	-8.45700E 03
.00000E 00	.00000E 00	1.16880E 04	.00000E 00	8.94100E 05	.00000E 00
.00000E 00	.00000E 00	.00000E 00	1.00000E 03	.00000E 00	.00000E 00
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.00000E 00	-8.45700E 03	.00000E 00	.00000E 00	.00000E 00	9.58470E 05
3 10					
4.34480E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
3 11					
1.83250E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	9.95000E 01	.00000E 00	.00000E 00	.00000E 00	-8.45700E 03
.00000E 00	.00000E 00	1.16880E 04	.00000E 00	8.94100E 05	.00000E 00
.00000E 00	.00000E 00	.00000E 00	1.00000E 03	.00000E 00	.00000E 00
.00000E 00	.00000E 00	8.94100E 05	.00000E 00	9.58470E 07	.00000E 00
.00000E 00	-8.45700E 03	.00000E 00	.00000E 00	.00000E 00	9.58470E 05
3 13					
6.36440E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
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.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
6 7					
4.99150E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	2.15000E 02	.00000E 00	.00000E 00	.00000E 00	-5.10000E 03
.00000E 00	.00000E 00	2.15610E 03	.00000E 00	9.10240E 04	.00000E 00
.00000E 00	.00000E 00	.00000E 00	1.70000E 04	.00000E 00	.00000E 00
.00000E 00	.00000E 00	5.10240E 04	.00000E 00	1.68580E 06	.00000E 00
.00000E 00	-5.10000E 03	.00000E 00	.00000E 00	.00000E 00	1.70000E 05
6 13					
4.99150E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	2.15000E 02	.00000E 00	.00000E 00	.00000E 00	-5.10000E 03
.00000E 00	.00000E 00	2.15610E 03	.00000E 00	5.10240E 04	.00000E 00
.00000E 00	.00000E 00	.00000E 00	1.70000E 04	.00000E 00	.00000E 00
.00000E 00	.00000E 00	5.10240E 04	.00000E 00	1.68580E 06	.00000E 00
.00000E 00	-5.10000E 03	.00000E 00	.00000E 00	.00000E 00	1.70000E 05
6 14					
6.21250E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00

.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
7 8					
3.30120E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	1.80000E 02	.00000E 00	.00000E 00	.00000E 00	-7.59000E 03
.00000E 00	.00000E 00	1.80000E 03	.00000E 00	7.50000E 04	.00000E 00
.00000E 00	.00000E 00	.00000E 00	4.20000E 04	.00000E 00	.00000E 00
.00000E 00	.00000E 00	7.50000E 04	.00000E 00	4.22200E 06	.00000E 00
.00000E 00	-7.59000E 03	.00000E 00	.00000E 00	.00000E 00	4.20000E 05
6 15					
8.13950E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
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.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
7 15					
1.15830E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
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.00000E 00	.00000E 00	6.22670E 03	.00000E 00	3.73600E 05	.00000E 00
.00000E 00	.00000E 00	.00000E 00	5.00000E 02	.00000E 00	.00000E 00
.00000E 00	.00000E 00	3.73600E 05	.00000E 00	3.10830E 07	.00000E 00
.00000E 00	-3.73600E 05	.00000E 00	.00000E 00	.00000E 00	3.10830E 07
8 9					
6.05000E 06	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	6.55380E 05	.00000E 00	.00000E 00	.00000E 00	-4.58770E 06
.00000E 00	.00000E 00	6.55380E 05	.00000E 00	4.58770E 06	.00000E 00
.00000E 00	.00000E 00	.00000E 00	3.00000E 07	.00000E 00	.00000E 00
.00000E 00	.00000E 00	4.58770E 06	.00000E 00	4.69350E 07	.00000E 00
.00000E 00	-4.58770E 06	.00000E 00	.00000E 00	.00000E 00	4.69350E 07
8 10					
5.80940E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	6.06000E 03	.00000E 00	.00000E 00	.00000E 00	-1.48000E 05
.00000E 00	.00000E 00	3.42870E 04	.00000E 00	8.36610E 05	.00000E 00
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.00000E 00	.00000E 00	8.36610E 05	.00000E 00	4.94930E 07	.00000E 00
.00000E 00	-1.48000E 05	.00000E 00	.00000E 00	.00000E 00	4.90000E 06
7-16					
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E2 23						
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	.00000E 00	4.94000E 04	.00000E 00	.00000E 00	.00000E 00	-8.88000E 05
	.00000E 00	.00000E 00	4.16000E 03	.00000E 00	7.89000E 04	.00000E 00
	.00000E 00	.00000E 00	.00000E 00	7.10000E 06	.00000E 00	.00000E 00
	.00000E 00	.00000E 00	7.89000E 04	.00000E 00	2.00000E 06	.00000E 00
	.00000E 00	-8.88000E 05	.00000E 00	.00000E 00	.00000E 00	2.95000E 07
E2 24						
	4.54000E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
	.00000E 00	6.06000E 03	.00000E 00	.00000E 00	.00000E 00	-1.48000E 05
	.00000E 00	.00000E 00	3.26900E 04	.00000E 00	7.97630E 05	.00000E 00
	.00000E 00	.00000E 00	.00000E 00	2.56000E 06	.00000E 00	.00000E 00
	.00000E 00	.00000E 00	7.97630E 05	.00000E 00	4.35170E 07	.00000E 00
	.00000E 00	-1.48000E 05	.00000E 00	.00000E 00	.00000E 00	4.90000E 06
E2 31						
	6.81060E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
E2 32						
	2.84790E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
	.00000E 00	2.84100E 02	.00000E 00	.00000E 00	.00000E 00	-1.64600E 04
	.00000E 00	.00000E 00	3.53840E 04	.00000E 00	1.74160E 06	.00000E 00
	.00000E 00	.00000E 00	.00000E 00	1.00000E 03	.00000E 00	.00000E 00
	.00000E 00	.00000E 00	1.74160E 06	.00000E 00	1.28390E 08	.00000E 00
	.00000E 00	-1.64600E 04	.00000E 00	.00000E 00	.00000E 00	1.28400E 06

24 25					
4.54000E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	6.06000E 03	.00000E 00	.00000E 00	.00000E 00	-1.48000E 05
.00000E 00	.00000E 00	3.26900E 04	.00000E 00	7.97630E 05	.00000E 00
.00000E 00	.00000E 00	.00000E 00	2.56000E 06	.00000E 00	.00000E 00
.00000E 00	.00000E 00	7.97630E 05	.00000E 00	4.35170E 07	.00000E 00
.00000E 00	-1.48000E 05	.00000E 00	.00000E 00	.00000E 00	4.90000E 06
24 32					
7.36930E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25 26					
2.65000E 06	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	4.94000E 04	.00000E 00	.00000E 00	.00000E 00	-8.88000E 05
.00000E 00	.00000E 00	4.16000E 03	.00000E 00	7.89000E 04	.00000E 00
.00000E 00	.00000E 00	.00000E 00	7.10000E 06	.00000E 00	.00000E 00
.00000E 00	.00000E 00	7.89000E 04	.00000E 00	2.00000E 06	.00000E 00
.00000E 00	-8.88000E 05	.00000E 00	.00000E 00	.00000E 00	2.95000E 07
25 27					
3.30120E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	1.80000E 02	.00000E 00	.00000E 00	.00000E 00	-7.59000E 03
.00000E 00	.00000E 00	1.80000E 03	.00000E 00	7.50000E 04	.00000E 00
.00000E 00	.00000E 00	.00000E 00	4.20000E 04	.00000E 00	.00000E 00
.00000E 00	.00000E 00	7.50000E 04	.00000E 00	4.22200E 06	.00000E 00
.00000E 00	-7.59000E 03	.00000E 00	.00000E 00	.00000E 00	4.20000E 05
25 31					
6.81060E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25 32					
2.84790E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	2.84100E 02	.00000E 00	.00000E 00	.00000E 00	-1.64600E 04
.00000E 00	.00000E 00	3.53840E 04	.00000E 00	1.74160E 06	.00000E 00
.00000E 00	.00000E 00	.00000E 00	1.00000E 03	.00000E 00	.00000E 00
.00000E 00	.00000E 00	1.74160E 06	.00000E 00	1.28390E 08	.00000E 00
.00000E 00	-1.64600E 04	.00000E 00	.00000E 00	.00000E 00	1.28400E 06
26 27					
1.14940E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
27 29					
5.33330E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	1.09470E 05	.00000E 00	.00000E 00	.00000E 00	-1.64210E 06
.00000E 00	.00000E 00	1.50670E 05	.00000E 00	2.26010E 06	.00000E 00
.00000E 00	.00000E 00	.00000E 00	9.10000E 06	.00000E 00	.00000E 00
.00000E 00	.00000E 00	2.26010E 06	.00000E 00	7.49010E 07	.00000E 00
.00000E 00	-1.64210E 06	.00000E 00	.00000E 00	.00000E 00	4.19650E 07
27 31					
1.43510E 05	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
.00000E 00	8.08900E 01	.00000E 00	.00000E 00	.00000E 00	-4.73200E 03

```
  .00000E 00    .00000E 00   1.01220E 04    .00000E 00   5.14710E 05    .00000E 00
  .00000E 00    .00000E 00    .00000E 00   5.00000E 02    .00000E 00    .00000E 00
  .00000E 00    .00000E 00   5.14710E 05    .00000E 00   3.69100E 07    .00000E 00
  .00000E 00  -4.73200E 03    .00000E 00    .00000E 00    .00000E 00   3.69100E 05
27 32
 1.16580E 05    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
20 28
 2.46150E 05    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00   1.83730E 04    .00000E 00    .00000E 00    .00000E 00  -5.97130E 05
  .00000E 00    .00000E 00   3.44560E 04    .00000E 00   1.11980E 06    .00000E 00
  .00000E 00    .00000E 00    .00000E 00   4.20000E 06    .00000E 00    .00000E 00
  .00000E 00    .00000E 00   1.11980E 06    .00000E 00   5.53170E 07    .00000E 00
  .00000E 00  -5.97130E 05    .00000E 00    .00000E 00    .00000E 00   2.74070E 07
4 35
 3.14220E 06    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00   4.59350E 04    .00000E 00    .00000E 00    .00000E 00  -5.16760E 05
  .00000E 00    .00000E 00   4.59350E 04    .00000E 00   5.16760E 05    .00000E 00
  .00000E 00    .00000E 00    .00000E 00   1.57040E 06    .00000E 00    .00000E 00
  .00000E 00    .00000E 00   5.16760E 05    .00000E 00   7.82690E 06    .00000E 00
  .00000E 00  -5.16760E 05    .00000E 00    .00000E 00    .00000E 00   7.82690E 06
5 36
 3.14220E 06    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00   4.59350E 04    .00000E 00    .00000E 00    .00000E 00  -5.16760E 05
  .00000E 00    .00000E 00   4.59350E 04    .00000E 00   5.16760E 05    .00000E 00
  .00000E 00    .00000E 00    .00000E 00   1.57040E 06    .00000E 00    .00000E 00
  .00000E 00    .00000E 00   5.16760E 05    .00000E 00   7.82690E 06    .00000E 00
  .00000E 00  -5.16760E 05    .00000E 00    .00000E 00    .00000E 00   7.82690E 06
20 29
 2.46150E 05    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00   1.83730E 04    .00000E 00    .00000E 00    .00000E 00  -5.97130E 05
  .00000E 00    .00000E 00   3.44560E 04    .00000E 00   1.11980E 06    .00000E 00
  .00000E 00    .00000E 00    .00000E 00   4.20000E 06    .00000E 00    .00000E 00
  .00000E 00    .00000E 00   1.11980E 06    .00000E 00   5.53170E 07    .00000E 00
  .00000E 00  -5.97130E 05    .00000E 00    .00000E 00    .00000E 00   2.74070E 07
20 33
 2.29000E 05    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00   1.22000E 03    .00000E 00    .00000E 00    .00000E 00  -4.27000E 04
  .00000E 00    .00000E 00   1.22000E 03    .00000E 00   4.27000E 04    .00000E 00
  .00000E 00    .00000E 00    .00000E 00   4.11000E 05    .00000E 00    .00000E 00
  .00000E 00    .00000E 00   4.27000E 04    .00000E 00   2.17150E 06    .00000E 00
  .00000E 00  -4.27000E 04    .00000E 00    .00000E 00    .00000E 00   2.17150E 06
31 32
 2.17390E 05    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00   6.99760E 04    .00000E 00    .00000E 00    .00000E 00  -3.21890E 06
  .00000E 00    .00000E 00   2.95280E 04    .00000E 00   1.35830E 06    .00000E 00
  .00000E 00    .00000E 00    .00000E 00   2.00000E 08    .00000E 00    .00000E 00
  .00000E 00    .00000E 00   1.35830E 06    .00000E 00   9.44370E 07    .00000E 00
  .00000E 00  -3.21890E 06    .00000E 00    .00000E 00    .00000E 00   4.30680E 08
31 33
 1.90500E 06    .00000E 00    .00000E 00    .00000E 00    .00000E 00    .00000E 00
  .00000E 00   5.33300E 06    .00000E 00    .00000E 00    .00000E 00  -4.80000E 07
  .00000E 00    .00000E 00   1.13000E 02    .00000E 00   1.21500E 03    .00000E 00
```

```
     .00000E 00     .00000E 00     .00000E 00     .00000E 00     .00000E 00     .00000E 00
     .00000E 00     .00000E 00    1.21500E 03     .00000E 00    1.53000E 05     .00000E 00
     .00000E 00   -4.80000E 07     .00000E 00     .00000E 00     .00000E 00    5.82000E 08
31 34
    1.08820E 06     .00000E 00     .00000E 00     .00000E 00     .00000E 00     .00000E 00
     .00000E 00    2.90420E 05     .00000E 00     .00000E 00     .00000E 00   -8.07060E 06
     .00000E 00     .00000E 00    2.90420E 05     .00000E 00    8.07060E 06     .00000E 00
     .00000E 00     .00000E 00     .00000E 00    1.45690E 08     .00000E 00     .00000E 00
     .00000E 00     .00000E 00    8.07060E 06     .00000E 00    4.81590E 08     .00000E 00
     .00000E 00   -8.07060E 06     .00000E 00     .00000E 00     .00000E 00    4.81590E 08
33 34
    1.87500E 06     .00000E 00     .00000E 00     .00000E 00     .00000E 00     .00000E 00
     .00000E 00    3.61020E 04     .00000E 00     .00000E 00     .00000E 00   -1.73290E 06
     .00000E 00     .00000E 00    3.61020E 04     .00000E 00    1.73290E 06     .00000E 00
     .00000E 00     .00000E 00     .00000E 00    2.27500E 07     .00000E 00     .00000E 00
     .00000E 00     .00000E 00    1.73290E 06     .00000E 00    1.12350E 08     .00000E 00
     .00000E 00   -1.73290E 06     .00000E 00     .00000E 00     .00000E 00    1.12350E 08

IJ,I,J,CBAR(I,J)
  1  1  2    1.00000E-02
  2  2  3    1.00000E-02
  3  2  6    1.00000E-02
  4  2  7    1.00000E-02
  5  2  8    1.00000E-02
  6  2 11    1.00000E-02
  7  2 13    1.00000E-02
  8  3  4    1.00000E-02
  9  3  5    1.00000E-02
 10  3  7    1.00000E-02
 11  3  8    1.00000E-02
 12  3 10    1.00000E-02
 13  3 11    1.00000E-02
 14  3 13    1.00000E-02
 15  6  7    1.00000E-02
 16  6 13    1.00000E-02
 17  6 14    1.00000E-02
 18  7  8    1.00000E-02
 19  6 15    1.00000E-02
 20  7 15    1.00000E-02
 21  8  9    1.00000E-02
 22  8 10    1.00000E-02
 23  7 16    1.00000E-02
 24  8 16    1.00000E-02
 25  8 30    1.00000E-02
 26 10 18    1.00000E-02
 27 10 11    1.00000E-02
 28 10 17    1.00000E-02
 29 11 12    1.00000E-02
 30 11 13    1.00000E-02
 31 10 16    1.00000E-02
 32 11 18    1.00000E-02
 33 11 37    1.00000E-02
 34 13 18    1.00000E-02
 35  6 19    1.00000E-02
 36 13 19    1.00000E-02
 37 14 15    1.00000E-02
 38 14 19    1.00000E-02
 39 14 20    1.00000E-02
```

40	14	21	1.00000E-02
41	14	27	1.00000E-02
42	15	16	1.00000E-02
43	15	21	1.00000E-02
44	15	22	1.00000E-02
45	16	17	1.00000E-02
46	16	22	1.00000E-02
47	17	18	1.00000E-02
48	17	22	1.00000E-02
49	17	24	1.00000E-02
50	17	25	1.00000E-02
51	18	19	1.00000E-02
52	18	25	1.00000E-02
53	19	25	1.00000E-02
54	19	27	1.00000E-02
55	20	21	1.00000E-02
56	20	27	1.00000E-02
57	20	31	1.00000E-02
58	21	22	1.00000E-02
59	21	23	1.00000E-02
60	21	28	1.00000E-02
61	21	31	1.00000E-02
62	21	32	1.00000E-02
63	22	23	1.00000E-02
64	22	24	1.00000E-02
65	22	31	1.00000E-02
66	22	32	1.00000E-02
67	24	25	1.00000E-02
68	24	32	1.00000E-02
69	25	26	1.00000E-02
70	25	27	1.00000E-02
71	25	31	1.00000E-02
72	25	32	1.00000E-02
73	26	27	1.00000E-02
74	27	29	1.00000E-02
75	27	31	1.00000E-02
76	27	32	1.00000E-02
77	20	28	1.00000E-02
78	4	35	1.00000E-02
79	5	36	1.00000E-02
80	20	29	1.00000E-02
81	20	33	1.00000E-02
82	31	32	1.00000E-02
83	31	33	1.00000E-02
84	31	34	1.00000E-02
85	33	34	1.00000E-02

KR TABLE SPECS, I,J,L,NP

2	7	3	4
2	7	5	4
2	8	1	3
2	11	1	3
2	13	3	4
2	13	5	4
3	7	1	3
3	8	3	4
3	8	5	4

3	11	3	4
3	11	5	4
3	13	1	3
6	7	3	4
6	7	5	4
6	13	3	4
6	13	5	4
6	15	1	3
6	19	1	3
7	8	1	4
7	8	3	4
7	8	5	4
7	15	1	4
7	15	2	4
7	15	3	4
7	15	5	4
7	15	6	4
7	16	1	3
8	9	2	4
8	9	3	4
8	9	4	4
8	9	5	4
8	9	6	4
8	10	3	4
8	10	5	4
8	16	1	4
8	16	3	4
8	16	5	4
8	30	1	3
10	11	3	4
10	11	5	4
10	16	1	3
10	18	1	3
11	12	2	4
11	12	3	4
11	12	4	4
11	12	5	4
11	12	6	4
11	13	1	4
11	13	3	4
11	13	5	4
11	18	1	4
11	18	3	4
11	18	5	4
11	37	1	3
13	18	1	3
13	19	1	4
13	19	2	4
13	19	3	4
13	19	5	4
13	19	6	4
14	15	3	4
14	15	5	4
14	19	3	4
14	19	5	4
14	21	1	3
14	27	1	3

```
15  16  3  4
15  16  5  4
15  21  2  4
15  21  3  4
15  21  5  4
15  21  6  4
15  22  1  3
16  17  3  4
16  17  5  4
16  22  1  4
16  22  3  4
16  22  5  4
17  18  3  4
17  18  5  4
17  22  1  3
17  25  1  3
18  19  3  4
18  19  5  4
18  25  1  4
18  25  3  4
18  25  5  4
19  25  1  3
19  27  2  4
19  27  3  4
19  27  5  4
19  27  6  4
20  21  3  4
20  21  5  4
20  27  3  4
20  27  5  4
21  22  3  4
21  22  5  4
21  23  1  3
21  31  5  4
21  32  1  3
22  24  3  4
22  24  5  4
22  31  1  3
22  32  5  4
24  25  3  4
24  25  5  4
25  27  3  4
25  27  5  4
25  31  1  3
25  32  5  4
26  27  1  3
27  31  5  4
27  32  1  3

KR TABLE FOR I,J,L =    2    7    3    TABLE ICH=   0
 1     .00000E 00    1.00000E 00
 2    1.93400E 01   -1.00000E 00
 3    2.18400E 01     .00000E 00
 4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    2    7    5    TABLE ICH=  10
 1     .00000E 00    1.00000E 00
 2    1.24000E-01   -1.00000E 00
```

```
   3      1.40000E-01       .00000E 00
   4      1.00000E 02       .00000E 00

KR TABLE FOR I,J,L =    2    8    1     TABLE ICH=  20
   1       .00000E 00      1.00000E 00
   2      1.08000E 00       .00000E 00
   3      1.00000E 02       .00000E 00

KR TABLE FOR I,J,L =    2   11    1     TABLE ICH=  30
   1       .00000E 00      1.00000E 00
   2      1.08000E 00       .00000E 00
   3      1.00000E 02       .00000E 00

KR TABLE FOR I,J,L =    2   13    3     TABLE ICH=  40
   1       .00000E 00      1.00000E 00
   2      1.93400E 01     -1.00000E 00
   3      2.18400E 01       .00000E 00
   4      1.00000E 02       .00000E 00

KR TABLE FOR I,J,L =    2   13    5     TABLE ICH=  50
   1       .00000E 00      1.00000E 00
   2      1.24000E-01     -1.00000E 00
   3      1.40000E-01       .00000E 00
   4      1.00000E 02       .00000E 00

KR TABLE FOR I,J,L =    3    7    1     TABLE ICH=  60
   1       .00000E 00      1.00000E 00
   2      1.08000E 00       .00000E 00
   3      1.00000E 02       .00000E 00

KR TABLE FOR I,J,L =    3    8    3     TABLE ICH=  70
   1       .00000E 00      1.00000E 00
   2      1.08600E 01     -1.00000E 00
   3      1.22400E 01       .00000E 00
   4      1.00000E 02       .00000E 00

KR TABLE FOR I,J,L =    3    8    5     TABLE ICH=  80
   1       .00000E 00      1.00000E 00
   2      7.10000E-02     -1.00000E 00
   3      8.00000E-02       .00000E 00
   4      1.00000E 02       .00000E 00

KR TABLE FOR I,J,L =    3   11    3     TABLE ICH=  90
   1       .00000E 00      1.00000E 00
   2      1.08600E 01     -1.00000E 00
   3      1.22400E 01       .00000E 00
   4      1.00000E 02       .00000E 00

KR TABLE FOR I,J,L =    3   11    5     TABLE ICH= 100
   1       .00000E 00      1.00000E 00
   2      7.10000E-02     -1.00000E 00
   3      8.00000E-02       .00000E 00
   4      1.00000E 02       .00000E 00

KR TABLE FOR I,J,L =    3   13    1     TABLE ICH= 110
   1       .00000E 00      1.00000E 00
   2      1.08000E 00       .00000E 00
   3      1.00000E 02       .00000E 00
```

```
KR TABLE FOR I,J,L =      6    7     3     TABLE ICH= 120
   1      .00000E 00    1.00000E 00
   2     1.60000E 00   -1.00000E 00
   3     1.78000E 00     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =      6    7     5     TABLE ICH= 130
   1      .00000E 00    1.00000E 00
   2     3.40000E-02   -1.00000E 00
   3     3.80000E-02     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =      6   13     3     TABLE ICH= 140
   1      .00000E 00    1.00000E 00
   2     1.60000E 00   -1.00000E 00
   3     1.78000E 00     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =      6   13     5     TABLE ICH= 150
   1      .00000E 00    1.00000E 00
   2     3.40000E-02   -1.00000E 00
   3     3.80000E-02     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =      6   15     1     TABLE ICH= 160
   1      .00000E 00    1.00000E 00
   2     7.80000E-01   -1.00000E 00
   3     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =      6   19     1     TABLE ICH= 170
   1      .00000E 00    1.00000E 00
   2     7.80000E-01   -1.00000E 00
   3     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =      7    8     1     TABLE ICH= 180
   1      .00000E 00    1.00000E 00
   2     5.00000E-01   -3.20000E-02
   3     1.17000E 01     .00000E 00
   4     1.67000E 01     .00000E 00

KR TABLE FOR I,J,L =      7    8     3     TABLE ICH= 190
   1      .00000E 00    1.00000E 00
   2     4.65000E 00   -1.00000E 00
   3     5.63000E 00     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =      7    8     5     TABLE ICH= 200
   1      .00000E 00    1.00000E 00
   2     5.60000E-02   -1.00000E 00
   3     6.30000E-02     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =      7   15     1     TABLE ICH= 210
   1      .00000E 00    1.00000E 00
   2     7.20000E-01   -3.20000E-02
   3     1.69000E 01     .00000E 00
   4     2.40000E 01     .00000E 00
```

```
KR TABLE FOR I,J,L =    7   15    2    TABLE ICH= 220
  1     .00000E 00    1.00000E 00
  2    1.15200E 01   -1.00000E 00
  3    1.29600E 01     .00000E 00
  4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    7   15    3    TABLE ICH= 230
  1     .00000E 00    1.00000E 00
  2    1.15200E 01   -1.00000E 00
  3    1.29600E 01     .00000E 00
  4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    7   15    5    TABLE ICH= 240
  1     .00000E 00    1.00000E 00
  2    9.60000E-02   -1.00000E 00
  3    1.08000E-01     .00000E 00
  4    4.80000E 00     .00000E 00

KR TABLE FOR I,J,L =    7   15    6    TABLE ICH= 250
  1     .00000E 00    1.00000E 00
  2    9.60000E-02   -1.00000E 00
  3    1.08000E-01     .00000E 00
  4    4.80000E 00     .00000E 00

KR TABLE FOR I,J,L =    7   16    1    TABLE ICH= 260
  1     .00000E 00    1.00000E 00
  2    1.02000E 00     .00000E 00
  3    2.90000E 01     .00000E 00

KR TABLE FOR I,J,L =    8    9    2    TABLE ICH= 270
  1     .00000E 00    1.00000E 00
  2    1.39200E-01   -1.00000E 00
  3    2.50500E-01     .00000E 00
  4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    8    9    3    TABLE ICH= 280
  1     .00000E 00    1.00000E 00
  2    1.28800E-01   -1.00000E 00
  3    2.31800E-01     .00000E 00
  4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    8    9    4    TABLE ICH= 290
  1     .00000E 00    1.00000E 00
  2    4.40000E-03   -1.00000E 00
  3    8.00000E-03     .00000E 00
  4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    8    9    5    TABLE ICH= 300
  1     .00000E 00    1.00000E 00
  2    1.08000E-02   -1.00000E 00
  3    1.94000E-02     .00000E 00
  4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    8    9    6    TABLE ICH= 310
  1     .00000E 00    1.00000E 00
  2    1.49000E-02   -1.00000E 00
  3    2.69000E-02     .00000E 00
  4    1.00000E 02     .00000E 00
```

```
KR TABLE FOR I,J,L =     8   10    3    TABLE ICH= 320
   1      .00000E 00    1.00000E 00
   2    8.80000E-01   -1.00000E 00
   3    9.80000E-01     .00000E 00
   4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =     8   10    5    TABLE ICH= 330
   1      .00000E 00    1.00000E 00
   2    1.80000E-02   -1.00000E 00
   3    2.00000E-02     .00000E 00
   4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =     8   16    1    TABLE ICH= 340
   1      .00000E 00    1.00000E 00
   2    7.20000E-01   -3.20000E-02
   3    1.69000E 01     .00000E 00
   4    2.40000E 01     .00000E 00

KR TABLE FOR I,J,L =     8   16    3    TABLE ICH= 350
   1      .00000E 00    1.00000E 00
   2    6.72000E 00   -1.00000E 00
   3    7.56000E 00     .00000E 00
   4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =     8   16    5    TABLE ICH= 360
   1      .00000E 00    1.00000E 00
   2    5.60000E-02   -1.00000E 00
   3    6.30000E-02     .00000E 00
   4    2.80000E 00     .00000E 00

KR TABLE FOR I,J,L =     8   30    1    TABLE ICH= 370
   1      .00000E 00    1.00000E 00
   2    8.00000E-03     .00000E 00
   3    1.00000E 01     .00000E 00

KR TABLE FOR I,J,L =    10   11    3    TABLE ICH= 380
   1      .00000E 00    1.00000E 00
   2    8.80000E-01   -1.00000E 00
   3    9.80000E-01     .00000E 00
   4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    10   11    5    TABLE ICH= 390
   1      .00000E 00    1.00000E 00
   2    1.80000E-02   -1.00000E 00
   3    2.00000E-02     .00000E 00
   4    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    10   15    1    TABLE ICH= 400
   1      .00000E 00    1.00000E 00
   2    7.80000E-01   -1.00000E 00
   3    1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    10   18    1    TABLE ICH= 410
   1      .00000E 00    1.00000E 00
   2    7.80000E-01   -1.00000E 00
   3    1.00000E 02     .00000E 00
```

```
KR TABLE FOR I,J,L =    11   12    2    TABLE ICH= 420
   1      .00000E 00    1.00000E 00
   2     1.39200E-01   -1.00000E 00
   3     2.50500E-01     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    11   12    3    TABLE ICH= 430
   1      .00000E 00    1.00000E 00
   2     1.28800E-01   -1.00000E 00
   3     2.31800E-01     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    11   12    4    TABLE ICH= 440
   1      .00000E 00    1.00000E 00
   2     4.40000E-03   -1.00000E 00
   3     8.00000E-03     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    11   12    5    TABLE ICH= 450
   1      .00000E 00    1.00000E 00
   2     1.08000E-02   -1.00000E 00
   3     1.94000E-02     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    11   12    6    TABLE ICH= 460
   1      .00000E 00    1.00000E 00
   2     1.49000E-02   -1.00000E 00
   3     2.69000E-02     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    11   13    1    TABLE ICH= 470
   1      .00000E 00    1.00000E 00
   2     5.00000E-01   -3.20000E-02
   3     1.17000E 01     .00000E 00
   4     1.67000E 01     .00000E 00

KR TABLE FOR I,J,L =    11   13    3    TABLE ICH= 480
   1      .00000E 00    1.00000E 00
   2     4.65000E 00   -1.00000E 00
   3     5.63000E 00     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    11   13    5    TABLE ICH= 490
   1      .00000E 00    1.00000E 00
   2     5.60000E-02   -1.00000E 00
   3     6.30000E-02     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    11   18    1    TABLE ICH= 500
   1      .00000E 00    1.00000E 00
   2     7.20000E-01   -3.20000E-02
   3     1.69000E 01     .00000E 00
   4     2.40000E 01     .00000E 00

KR TABLE FOR I,J,L =    11   18    3    TABLE ICH= 510
   1      .00000E 00    1.00000E 00
   2     6.72000E 00   -1.00000E 00
   3     7.56000E 00     .00000E 00
   4     1.00000E 02     .00000E 00
```

```
KR TABLE FOR I,J,L =   11   18    5    TABLE ICH= 520
  1      .00000E 00    1.00000E 00
  2     5.60000E-02   -1.00000E 00
  3     6.30000E-02     .00000E 00
  4     2.80000E 00     .00000E 00

KR TABLE FOR I,J,L =   11   37    1    TABLE ICH= 530
  1      .00000E 00    1.00000E 00
  2     8.00000E-03     .00000E 00
  3     1.00000E 01     .00000E 00

KR TABLE FOR I,J,L =   13   18    1    TABLE ICH= 540
  1      .00000E 00    1.00000E 00
  2     1.02000E 00     .00000E 00
  3     2.90000E 01     .00000E 00

KR TABLE FOR I,J,L =   13   19    1    TABLE ICH= 550
  1      .00000E 00    1.00000E 00
  2     7.20000E-01   -3.20000E-02
  3     1.69000E 01     .00000E 00
  4     2.40000E 01     .00000E 00

KR TABLE FOR I,J,L =   13   19    2    TABLE ICH= 560
  1      .00000E 00    1.00000E 00
  2     1.15200E 01   -1.00000E 00
  3     1.29600E 01     .00000E 00
  4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =   13   19    3    TABLE ICH= 570
  1      .00000E 00    1.00000E 00
  2     1.15200E 01   -1.00000E 00
  3     1.29600E 01     .00000E 00
  4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =   13   19    5    TABLE ICH= 580
  1      .00000E 00    1.00000E 00
  2     9.60000E-02   -1.00000E 00
  3     1.08000E-01     .00000E 00
  4     4.80000E 00     .00000E 00

KR TABLE FOR I,J,L =   13   19    6    TABLE ICH= 590
  1      .00000E 00    1.00000E 00
  2     9.60000E-02   -1.00000E 00
  3     1.08000E-01     .00000E 00
  4     4.80000E 00     .00000E 00

KR TABLE FOR I,J,L =   14   15    3    TABLE ICH= 600
  1      .00000E 00    1.00000E 00
  2     1.60000E 00   -1.00000E 00
  3     1.78000E 00     .00000E 00
  4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =   14   15    5    TABLE ICH= 610
  1      .00000E 00    1.00000E 00
  2     3.40000E-02   -1.00000E 00
  3     3.80000E-02     .00000E 00
  4     1.00000E 02     .00000E 00
```

```
KR TABLE FOR I,J,L =     14   19    3     TABLE ICH= 620
  1       .00000E 00    1.00000E 00
  2      1.60000E 00   -1.00000E 00
  3      1.78000E 00     .00000E 00
  4      1.00000E 02     .00000E 00
KR TABLE FOR I,J,L =     14   19    5     TABLE ICH= 630
  1       .00000E 00    1.00000E 00
  2      3.40000E-02   -1.00000E 00
  3      3.80000E-02     .00000E 00
  4      1.00000E 02     .00000E 00
KR TABLE FOR I,J,L =     14   21    1     TABLE ICH= 640
  1       .00000E 00    1.00000E 00
  2      7.80000E-01   -1.00000E 00
  3      1.00000E 02     .00000E 00
KR TABLE FOR I,J,L =     14   27    1     TABLE ICH= 650
  1       .00000E 00    1.00000E 00
  2      7.80000E-01   -1.00000E 00
  3      1.00000E 02     .00000E 00
KR TABLE FOR I,J,L =     15   16    3     TABLE ICH= 660
  1       .00000E 00    1.00000E 00
  2      4.65000E 00   -1.00000E 00
  3      5.63000E 00     .00000E 00
  4      1.00000E 02     .00000E 00
KR TABLE FOR I,J,L =     15   16    5     TABLE ICH= 670
  1       .00000E 00    1.00000E 00
  2      5.60000E-02   -1.00000E 00
  3      6.30000E-02     .00000E 00
  4      1.00000E 02     .00000E 00
KR TABLE FOR I,J,L =     15   21    2     TABLE ICH= 680
  1       .00000E 00    1.00000E 00
  2      1.15200E 01   -1.00000E 00
  3      1.29600E 01     .00000E 00
  4      1.00000E 02     .00000E 00
KR TABLE FOR I,J,L =     15   21    3     TABLE ICH= 690
  1       .00000E 00    1.00000E 00
  2      1.15200E 01   -1.00000E 00
  3      1.29600E 01     .00000E 00
  4      1.00000E 02     .00000E 00
KR TABLE FOR I,J,L =     15   21    5     TABLE ICH= 700
  1       .00000E 00    1.00000E 00
  2      9.60000E-02   -1.00000E 00
  3      1.08000E-01     .00000E 00
  4      1.00000E 02     .00000E 00
KR TABLE FOR I,J,L =     15   21    6     TABLE ICH= 710
  1       .00000E 00    1.00000E 00
  2      9.60000E-02   -1.00000E 00
  3      1.08000E-01     .00000E 00
  4      1.00000E 02     .00000E 00
```

```
KR TABLE FOR I,J,L =   15   22    1    TABLE ICH= 720
  1      .00000E 00     1.00000E 00
  2     1.03000E 00      .00000E 00
  3     2.90000E 01      .00000E 00

KR TABLE FOR I,J,L =   16   17    3    TABLE ICH= 730
  1      .00000E 00     1.00000E 00
  2     8.80000E-01    -1.00000E 00
  3     9.80000E-01      .00000E 00
  4     1.00000E 02      .00000E 00

KR TABLE FOR I,J,L =   16   17    5    TABLE ICH= 740
  1      .00000E 00     1.00000E 00
  2     1.80000E-02    -1.00000E 00
  3     2.00000E-02      .00000E 00
  4     1.00000E 02      .00000E 00

KR TABLE FOR I,J,L =   16   22    1    TABLE ICH= 750
  1      .00000E 00     1.00000E 00
  2     7.30000E-01    -3.20000E-02
  3     1.72000E 01      .00000E 00
  4     2.44000E 01      .00000E 00

KR TABLE FOR I,J,L =   16   22    3    TABLE ICH= 760
  1      .00000E 00     1.00000E 00
  2     6.95400E 00    -1.00000E 00
  3     7.80800E 00      .00000E 00
  4     1.00000E 02      .00000E 00

KR TABLE FOR I,J,L =   16   22    5    TABLE ICH= 770
  1      .00000E 00     1.00000E 00
  2     5.70000E-02    -1.00000E 00
  3     6.40000E-02      .00000E 00
  4     2.80000E 00      .00000E 00

KR TABLE FOR I,J,L =   17   18    3    TABLE ICH= 780
  1      .00000E 00     1.00000E 00
  2     8.50000E-01    -1.00000E 00
  3     9.80000E-01      .00000E 00
  4     1.00000E 02      .00000E 00

KR TABLE FOR I,J,L =   17   18    5    TABLE ICH= 790
  1      .00000E 00     1.00000E 00
  2     1.80000E-02    -1.00000E 00
  3     2.00000E-02      .00000E 00
  4     1.00000E 02      .00000E 00

KR TABLE FOR I,J,L =   17   22    1    TABLE ICH= 800
  1      .00000E 00     1.00000E 00
  2     7.80000E-01    -1.00000E 00
  3     1.00000E 02      .00000E 00

KR TABLE FOR I,J,L =   17   25    1    TABLE ICH= 810
  1      .00000E 00     1.00000E 00
  2     7.80000E-01    -1.00000E 00
  3     1.00000E 02      .00000E 00
```


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KR TABLE FOR I,J,L =    18   19     3     TABLE ICH= 820
   1      .00000E 00    1.00000E 00
   2     4.65000E 00   -1.00000E 00
   3     5.63000E 00     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    18   19     5     TABLE ICH= 830
   1      .00000E 00    1.00000E 00
   2     5.60000E-02   -1.00000E 00
   3     6.30000E-02     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    13   25     1     TABLE ICH= 840
   1      .00000E 00    1.00000E 00
   2     7.30000E-01   -3.20000E-02
   3     1.72000E 01     .00000E 00
   4     2.44000E 01     .00000E 00

KR TABLE FOR I,J,L =    18   25     3     TABLE ICH= 850
   1      .00000E 00    1.00000E 00
   2     6.95400E 00   -1.00000E 00
   3     7.80800E 00     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    18   25     5     TABLE ICH= 860
   1      .00000E 00    1.00000E 00
   2     5.70000E-02   -1.00000E 00
   3     6.40000E-02     .00000E 00
   4     2.80000E 00     .00000E 00

KR TABLE FOR I,J,L =    19   25     1     TABLE ICH= 870
   1      .00000E 00    1.00000E 00
   2     1.03000E 00     .00000E 00
   3     2.90000E 01     .00000E 00

KR TABLE FOR I,J,L =    19   27     2     TABLE ICH= 880
   1      .00000E 00    1.00000E 00
   2     1.15200E 01   -1.00000E 00
   3     1.29600E 01     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    19   27     3     TABLE ICH= 890
   1      .00000E 00    1.00000E 00
   2     1.15200E 01   -1.00000E 00
   3     1.29600E 01     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    19   27     5     TABLE ICH= 900
   1      .00000E 00    1.00000E 00
   2     9.60000E-02   -1.00000E 00
   3     1.08000E-01     .00000E 00
   4     1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    19   27     6     TABLE ICH= 910
   1      .00000E 00    1.00000E 00
   2     9.60000E-02   -1.00000E 00
   3     1.08000E-01     .00000E 00
   4     1.00000E 02     .00000E 00
```

```
KR TABLE FOR I,J,L =    20    21    3      TABLE ICH= 920
   1      .00000E 00     1.00000E 00
   2     1.60000E 00    -1.00000E 00
   3     1.78000E 00      .00000E 00
   4     1.00000E 02      .00000E 00
KR TABLE FOR I,J,L =    20    21    5      TABLE ICH= 930
   1      .00000E 00     1.00000E 00
   2     3.40000E-02    -1.00000E 00
   3     3.80000E-02      .00000E 00
   4     1.00000E 02      .00000E 00
KR TABLE FOR I,J,L =    20    27    3      TABLE ICH= 940
   1      .00000E 00     1.00000E 00
   2     1.60000E 00    -1.00000E 00
   3     1.78000E 00      .00000E 00
   4     1.00000E 02      .00000E 00
KR TABLE FOR I,J,L =    20    27    5      TABLE ICH= 950
   1      .00000E 00     1.00000E 00
   2     3.40000E-02    -1.00000E 00
   3     3.80000E-02      .00000E 00
   4     1.00000E 02      .00000E 00
KR TABLE FOR I,J,L =    21    22    3      TABLE ICH= 960
   1      .00000E 00     1.00000E 00
   2     4.65000E 00    -1.00000E 00
   3     5.63000E 00      .00000E 00
   4     1.00000E 02      .00000E 00
KR TABLE FOR I,J,L =    21    22    5      TABLE ICH= 970
   1      .00000E 00     1.00000E 00
   2     5.60000E-02    -1.00000E 00
   3     6.30000E-02      .00000E 00
   4     1.00000E 02      .00000E 00
KR TABLE FOR I,J,L =    21    23    1      TABLE ICH= 980
   1      .00000E 00     1.00000E 00
   2     6.10000E-01      .00000E 00
   3     1.74000E 01      .00000E 00
KR TABLE FOR I,J,L =    21    31    5      TABLE ICH= 990
   1      .00000E 00     1.00000E 00
   2     8.20000E-02    -1.00000E 00
   3     9.20000E-02      .00000E 00
   4     1.00000E 02      .00000E 00
KR TABLE FOR I,J,L =    21    32    1      TABLE ICH=1000
   1      .00000E 00     1.00000E 00
   2     5.70000E-01    -1.00000E 00
   3     1.00000E 02      .00000E 00
KR TABLE FOR I,J,L =    22    24    3      TABLE ICH=1010
   1      .00000E 00     1.00000E 00
   2     8.80000E-01    -1.00000E 00
   3     9.80000E-01      .00000E 00
   4     1.00000E 02      .00000E 00
```

```
KR TABLE FOR I,J,L =    22   24    5     TABLE ICH=1020
   1       .00000E 00    1.00000E 00
   2      1.80000E-02   -1.00000E 00
   3      2.00000E-02     .00000E 00
   4      1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    22   31    1     TABLE ICH=1030
   1       .00000E 00    1.00000E 00
   2      5.70000E-01   -1.00000E 00
   3      1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    22   32    5     TABLE ICH=1040
   1       .00000E 00    1.00000E 00
   2      4.50000E-02   -1.00000E 00
   3      5.10000E-02     .00000E 00
   4      1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    24   25    3     TABLE ICH=1050
   1       .00000E 00    1.00000E 00
   2      8.80000E-01   -1.00000E 00
   3      9.80000E-01     .00000E 00
   4      1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    24   25    5     TABLE ICH=1060
   1       .00000E 00    1.00000E 00
   2      1.80000E-02   -1.00000E 00
   3      2.00000E-02     .00000E 00
   4      1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    25   27    3     TABLE ICH=1070
   1       .00000E 00    1.00000E 00
   2      4.65000E 00   -1.00000E 00
   3      5.63000E 00     .00000E 00
   4      1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    25   27    5     TABLE ICH=1080
   1       .00000E 00    1.00000E 00
   2      5.60000E-02   -1.00000E 00
   3      6.30000E-02     .00000E 00
   4      1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    25   31    1     TABLE ICH=1090
   1       .00000E 00    1.00000E 00
   2      5.70000E-01   -1.00000E 00
   3      1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    25   32    5     TABLE ICH=1100
   1       .00000E 00    1.00000E 00
   2      4.50000E-02   -1.00000E 00
   3      5.10000E-02     .00000E 00
   4      1.00000E 02     .00000E 00

KR TABLE FOR I,J,L =    26   27    1     TABLE ICH=1110
   1       .00000E 00    1.00000E 00
   2      6.10000E-01     .00000E 00
   3      1.74000E 01     .00000E 00
```

```
KR TABLE FOR I,J,L =    27   31    5     TABLE ICH=1120
   1      .00000E 00     1.00000E 00
   2     8.20000E-02    -1.00000E 00
   3     9.20000E-02      .00000E 00
   4     1.00000E 02      .00000E 00

KR TABLE FOR I,J,L =    27   32    1     TABLE ICH=1130
   1      .00000E 00     1.00000E 00
   2     5.70000E-01    -1.00000E 00
   3     1.00000E 02      .00000E 00

IJ,I,J,VMAX(I,J,1-6)
  4  2  7    2.49500E 00   1.00000E 02   1.00000E 02   1.00000E 02   2.80000E-01   1.00000E 02
  5  2  8    1.55000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
  6  2 11    1.55000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
  7  2 13    2.49500E 00   1.00000E 02   1.00000E 02   1.00000E 02   2.80000E-01   1.00000E 02
 10  3  7    1.55000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 11  3  8    2.93500E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.60000E-01   1.00000E 02
 13  3 11    2.93500E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.60000E-01   1.00000E 02
 14  3 13    1.55000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 15  6  7    7.52000E-01   1.00000E 02   1.00000E 02   1.00000E 02   7.60000E-02   1.00000E 02
 16  6 13    7.52000E-01   1.00000E 02   1.00000E 02   1.00000E 02   7.60000E-02   1.00000E 02
 19  6 15    2.06000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 35  6 19    2.06000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 18  7  8    1.33000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.26000E-01   1.00000E 02
 20  7 15    1.92000E 00   1.00000E 02   1.00000E 02   1.00000E 02   2.16000E-01   1.00000E 02
 23  7 16    1.10000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 21  8  9    2.16000E-02   1.10000E 01   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 22  8 10    7.84000E-01   1.00000E 02   1.00000E 02   1.00000E 02   4.00000E-02   1.00000E 02
 24  8 16    1.92000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.26000E-01   1.00000E 02
 25  8 30    8.00000E-03   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 27 10 11    7.84000E-01   1.00000E 02   1.00000E 02   1.00000E 02   4.00000E-02   1.00000E 02
 31 10 16    2.06000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 26 10 18    2.06000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 29 11 12    2.16000E-02   1.10000E 01   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 30 11 13    1.33000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.26000E-01   1.00000E 02
 32 11 18    1.92000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.26000E-01   1.00000E 02
 33 11 37    8.00000E-03   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 34 13 18    1.10000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 36 13 19    1.92000E 00   1.00000E 02   1.00000E 02   1.00000E 02   2.16000E-01   1.00000E 02
 37 14 15    7.52000E-01   1.00000E 02   1.00000E 02   1.00000E 02   7.60000E-02   1.00000E 02
 38 14 19    7.52000E-01   1.00000E 02   1.00000E 02   1.00000E 02   7.60000E-02   1.00000E 02
 40 14 21    2.06000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 41 14 27    2.06000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 42 15 16    1.33000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.26000E-01   1.00000E 02
 43 15 21    1.92000E 00   1.00000E 02   1.00000E 02   1.00000E 02   2.16000E-01   1.00000E 02
 44 15 22    1.10000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 45 16 17    7.84000E-01   1.00000E 02   1.00000E 02   1.00000E 02   4.00000E-02   1.00000E 02
 46 16 22    1.92000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.26000E-01   1.00000E 02
 47 17 18    7.84000E-01   1.00000E 02   1.00000E 02   1.00000E 02   4.00000E-02   1.00000E 02
 48 17 22    2.06000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 50 17 25    2.06000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 51 18 19    1.33000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.26000E-01   1.00000E 02
 52 18 25    1.92000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.26000E-01   1.00000E 02
 53 19 25    1.10000E 00   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02   1.00000E 02
 54 19 27    1.92000E 00   1.00000E 02   1.00000E 02   1.00000E 02   2.16000E-01   1.00000E 02
 55 20 21    7.52000E-01   1.00000E 02   1.00000E 02   1.00000E 02   7.60000E-02   1.00000E 02
```

56	20	27	7.52000E-01	1.00000E 02	1.00000E 02	1.00000E 02	7.60000E-02	1.00000E 02
58	21	22	1.33000E 00	1.00000E 02	1.00000E 02	1.00000E 02	1.26000E-01	1.00000E 02
59	21	23	9.75000E-01	1.00000E 02	1.00000E 02	1.00000E 01	1.00000E 01	1.00000E 01
61	21	31	1.28400E 00	1.00000E 02	1.00000E 02	1.00000E 02	9.20000E-02	1.00000E 02
62	21	32	1.52400E 00	1.00000E 02	1.00000E 02	1.00000E 02	1.00000E 02	1.00000E 02
63	22	23	6.00000E-03	1.00000E 02	1.00000E 02	6.00000E-03	1.00000E 02	1.00000E-02
64	22	24	7.84000E-01	1.00000E 02	1.00000E 02	1.00000E 02	4.00000E-02	1.00000E 02
65	22	31	1.52400E 00	1.00000E 02	1.00000E 02	1.00000E 02	1.00000E 02	1.00000E 02
66	22	32	1.56800E 00	1.00000E 02	1.00000E 02	1.00000E 02	5.10000E-02	1.00000E 02
67	24	25	7.84000E-01	1.00000E 02	1.00000E 02	1.00000E 02	4.00000E-02	1.00000E 02
69	25	26	6.00000E-03	1.00000E 02	1.00000E 02	6.00000E-03	1.00000E 02	1.00000E-02
70	25	27	1.33000E 00	1.00000E 02	1.00000E 02	1.00000E 02	1.26000E-01	1.00000E 02
71	25	31	1.52400E 00	1.00000E 02	1.00000E 02	1.00000E 02	1.00000E 02	1.00000E 02
72	25	32	1.56800E 00	1.00000E 02	1.00000E 02	1.00000E 02	5.10000E-02	1.00000E 02
73	25	27	9.75000E-01	1.00000E 02	1.00000E 02	1.00000E 01	1.00000E 01	1.00000E 01
75	27	31	1.28400E 00	1.00000E 02	1.00000E 02	1.00000E 02	9.20000E-02	1.00000E 02
76	27	32	1.52400E 00	1.00000E 02	1.00000E 02	1.00000E 02	1.00000E 02	1.00000E 02

INDP = 0

DRI(IJ) INDICATORS

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

PLASTIC-YIELD CRITERIA DATA
START TIME= -.1000E 01 NO. OF PROPERTY SETS= 0NO. OF ELTS= 0
*****END OF PLASTIC-YIELD CRITERIA INPUT *****

****

MAXFREQ= 821.7HZ PERIOD= .001217 PER4TH= .000304

****

MASS	OMEGA 1	2	3	4	5	6	MAX
1	158.34	310.28	727.57	591.59	569.02	263.72	727.57
2	290.85	286.10	633.35	226.76	231.37	105.66	633.35
3	451.90	396.36	238.00	226.34	246.10	190.32	451.90
4	1205.66	1193.58	2356.47	2574.12	711.29	1761.09	2574.12
5	612.08	903.92	2509.18	3371.28	722.77	1441.53	3371.28
6	699.30	455.64	124.16	140.66	7.29	18.38	699.30
7	699.30	243.01	739.29	304.32	273.45	179.77	739.29
8	294.55	1358.80	1915.27	443.04	374.40	151.91	1915.27
9	1250.02	3330.89	2790.63	588.37	458.25	1296.24	3330.89
10	259.88	534.49	115.61	472.22	59.26	78.11	534.49
11	893.76	1204.21	1400.15	327.56	336.64	175.10	1400.15
12	2044.76	2891.28	1815.91	544.10	504.80	1527.76	2891.28
13	798.42	432.00	704.85	69.33	238.85	180.05	798.42
14	749.35	470.34	97.10	145.92	9.26	23.27	749.35
15	921.12	380.98	843.56	196.18	345.88	319.03	921.12
16	398.52	332.12	292.16	262.32	335.62	64.00	398.52
17	243.66	428.54	104.02	295.63	22.18	69.48	428.54
18	424.56	357.45	238.43	262.32	335.63	64.09	424.56
19	994.87	469.37	780.39	196.18	346.09	319.23	994.87

20	641.50	575.50	352.96	260.08	149.40	178.42	641.50
21	1136.86	602.48	1065.54	86.50	302.56	165.33	1136.86
22	1359.18	502.14	664.74	117.13	297.20	132.87	1359.18
23	1370.50	910.32	432.99	227.78	50.35	406.92	1370.50
24	220.88	517.92	170.60	224.91	58.77	76.49	517.92
25	1963.31	1447.10	300.78	254.40	386.63	139.28	1963.31
26	2453.13	1789.51	1003.93	292.68	160.57	427.82	2453.13
27	1101.67	456.76	1028.71	151.06	323.36	160.51	1101.67
28	525.90	266.80	488.81	787.49	327.02	194.94	787.49
29	619.23	487.31	540.43	476.96	232.30	167.71	619.23
30	.00	.00	5162.84	.00	.00	.00	5162.84
31	1445.60	2654.45	1970.08	657.24	542.27	428.40	2654.45
32	824.72	419.35	621.43	331.30	302.10	248.84	824.72
33	616.97	1318.73	1079.46	529.21	438.49	661.80	1318.73
34	228.84	300.47	730.72	693.49	997.94	2297.00	2297.00
35	308.74	289.20	2188.66	239.02	211.48	160.85	2188.66
36	308.74	289.20	2188.66	239.02	211.48	160.85	2188.66
37	.00	.00	5162.84	.00	.00	.00	5162.84

****

MODEL PROPERTIES
CENTER OF GRAVITY-INCHES
XCG= .323581E 03   YCG=-.544386E-01   ZCG= .110538E 02
WEIGHT-LB
.250102E 05
INERTIAS LB-IN-SEC**2
IX= .330689E 06   IY= .212730E 07   IZ= .196009E 07

IJ,THEIJ(IJ),PSIIJ(IJ)

IJ	THEIJ(IJ)	PSIIJ(IJ)
1	-1.75724E 00	.00000E 00
2	-1.59842E 00	.00000E 00
3	-3.06811E 00	.00000E 00
4	-1.26383E-01	2.83651E 00
5	-5.81714E-01	2.82240E 00
6	-5.81714E-01	-2.82240E 00
7	-1.26383E-01	-2.83651E 00
8	4.22752E-01	8.13543E-01
9	4.22752E-01	-8.13543E-01
10	4.66078E-01	2.83126E 00
11	-3.91977E-02	2.81695E 00
12	-3.10024E 00	.00000E 00
13	-3.91977E-02	-2.81695E 00
14	4.66078E-01	-2.83126E 00
15	-1.87035E-01	1.57080E 00
16	-1.87035E-01	-1.57080E 00
17	-3.14159E 00	.00000E 00
18	-1.54296E 00	1.57080E 00
19	-6.82728E-02	2.77191E 00
20	-3.14159E 00	.00000E 00
21	-5.70023E-01	1.90935E 00
22	.00000E 00	-1.57080E 00
23	-6.02767E-01	3.12243E 00
24	-3.14159E 00	.00000E 00
25	-1.57080E 00	.00000E 00
26	.00000E 00	-2.75535E 00
27	.00000E 00	-1.57080E 00

28	-3.14159E 00	.00000E 00
29	-5.70023E-01	-1.90935E 00
30	1.54296E 00	1.57080E 00
31	.00000E 00	2.75535E 00
32	-3.14159E 00	.00000E 00
33	-1.57080E 00	.00000E 00
34	-6.02767E-01	-3.12243E 00
35	-6.82728E-02	-2.77191E 00
36	-3.14159E 00	.00000E 00
37	-1.87035E-01	1.57080E 00
38	-1.87035E-01	-1.57080E 00
39	-3.14159E 00	.00000E 00
40	-6.72995E-02	2.77744E 00
41	-6.72995E-02	-2.77744E 00
42	-1.54296E 00	1.57080E 00
43	-3.14159E 00	.00000E 00
44	-5.95074E-01	3.12274E 00
45	.00000E 00	-1.57080E 00
46	-3.14159E 00	.00000E 00
47	.00000E 00	-1.57080E 00
48	.00000E 00	2.76109E 00
49	-3.14159E 00	.00000E 00
50	.00000E 00	-2.76109E 00
51	1.54296E 00	1.57080E 00
52	-3.14159E 00	.00000E 00
53	-5.95074E-01	-3.12274E 00
54	-3.14159E 00	.00000E 00
55	-1.87035E-01	1.57080E 00
56	-1.87035E-01	-1.57080E 00
57	2.69858E 00	.00000E 00
58	-1.54296E 00	1.57080E 00
59	-1.22343E 00	2.59304E 00
60	7.06701E-01	3.05672E 00
61	4.70972E-01	-2.68221E 00
62	-3.48472E-01	-2.68221E 00
63	-1.56065E-01	2.65742E 00
64	.00000E 00	-1.57080E 00
65	9.09137E-01	-2.66274E 00
66	3.97763E-01	-2.66274E 00
67	.00000E 00	-1.57080E 00
68	2.69945E 00	.00000E 00
69	-1.56065E-01	-2.65742E 00
70	1.54296E 00	1.57080E 00
71	9.09137E-01	2.66274E 00
72	3.97763E-01	2.66274E 00
73	1.22343E 00	5.48549E-01
74	7.06701E-01	-3.05672E 00
75	4.70972E-01	2.68221E 00
76	-3.48472E-01	2.68221E 00
77	1.99555E-01	2.01266E 00
78	1.57080E 00	.00000E 00
79	1.57080E 00	.00000E 00
80	1.99555E-01	-2.01266E 00
81	3.08777E 00	.00000E 00
82	-1.57080E 00	.00000E 00
83	-1.15464E 00	.00000E 00
84	1.17229E 00	.00000E 00
85	1.51379E 00	.00000E 00

OUTPUT AT TIME = 0

CH-47A POST TEST MODEL 36 NODES V=340,0,522 DEG=0,-8.7,0

TIME = .00000000

	X / XDOT / U / UDOT / XACCEL	Y / YDOT / V / VDOT / YACCEL	Z / ZDOT / W / WDOT / ZACCEL	PHI / PHIDOT / P / PDOT	THETA / THETADOT / Q / QDOT	PSI / PSIDOT / R / RDOT
MASS 1	2.48281E 02	-5.44386E-02	-1.52309E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.34060E 02	.00000E 00	4.93572E 02	.00000E 00	1.14500E-01	.00000E 00
	4.04855E 02	.00000E 00	4.37380E 02	.00000E 00	1.14500E-01	.00000E 00
	8.28999E 00	.00000E 00	4.27917E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 2	2.36932E 02	-5.44386E-02	-1.20044E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.37754E 02	.00000E 00	4.94871E 02	.00000E 00	1.14500E-01	.00000E 00
	4.08704E 02	.00000E 00	4.38106E 02	.00000E 00	1.14500E-01	.00000E 00
	8.20687E 00	.00000E 00	4.28358E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 3	2.19745E 02	-5.44386E-02	-2.52832E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.48604E 02	.00000E 00	4.96839E 02	.00000E 00	1.14500E-01	.00000E 00
	4.19726E 02	.00000E 00	4.38411E 02	.00000E 00	1.14500E-01	.00000E 00
	8.17200E 00	.00000E 00	4.29620E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 4	2.41332E 02	2.09456E 01	-3.51321E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.47477E 02	.00000E 00	4.94367E 02	.00000E 00	1.14500E-01	.00000E 00
	4.18238E 02	.00000E 00	4.36138E 02	.00000E 00	1.14500E-01	.00000E 00
	8.43224E 00	.00000E 00	4.29449E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 5	2.41332E 02	-2.10544E 01	-3.51321E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.47477E 02	.00000E 00	4.94367E 02	.00000E 00	1.14500E-01	.00000E 00
	4.18238E 02	.00000E 00	4.36138E 02	.00000E 00	1.14500E-01	.00000E 00
	8.43224E 00	.00000E 00	4.29449E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 6	8.93259E 01	-5.44386E-02	-1.31628E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.36428E 02	.00000E 00	5.11772E 02	.00000E 00	1.14500E-01	.00000E 00
	4.09948E 02	.00000E 00	4.55013E 02	.00000E 00	1.14500E-01	.00000E 00
	6.27101E 00	.00000E 00	4.28500E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 7	8.79952E 01	4.64456E 01	-1.22929E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.37424E 02	.00000E 00	5.11925E 02	.00000E 00	1.14500E-01	.00000E 00

CH-47A POST TEST MODEL 36 MODES V=340,0,522 DEG=0,-8.7,0

TIME = .00000000

	X / XDOT / U / UDOT / XACCEL	Y / YDOT / V / VDOT / YACCEL	Z / ZDOT / W / WDOT / ZACCEL	PHI / PHIDOT / P / PDOT	THETA / THETADOT / Q / QDOT	PSI / PSIDOT / R / RDOT
	4.10956E 02	.00000E 00	4.55013E 02	.00000E 00	1.14500E-01	.00000E 00
	6.27101E 00	.00000E 00	4.28616E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 8	7.55046E 01	4.87456E 01	-4.12788E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.46773E 02	.00000E 00	5.13355E 02	.00000E 00	1.14500E-01	.00000E 00
	4.20413E 02	.00000E 00	4.55013E 02	.00000E 00	1.14500E-01	.00000E 00
	6.27101E 00	.00000E 00	4.29699E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 9	6.91029E 01	6.29456E 01	-3.24959E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.47779E 02	.00000E 00	5.14088E 02	.00000E 00	1.14500E-01	.00000E 00
	4.21518E 02	.00000E 00	4.55586E 02	.00000E 00	1.14500E-01	.00000E 00
	6.20546E 00	.00000E 00	4.29825E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 10	7.55046E 01	-5.44386E-02	-4.12788E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.46773E 02	.00000E 00	5.13355E 02	.00000E 00	1.14500E-01	.00000E 00
	4.20413E 02	.00000E 00	4.55013E 02	.00000E 00	1.14500E-01	.00000E 00
	6.27101E 00	.00000E 00	4.29699E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 11	7.55046E 01	-4.88544E 01	-4.12788E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.46773E 02	.00000E 00	5.13355E 02	.00000E 00	1.14500E-01	.00000E 00
	4.20413E 02	.00000E 00	4.55013E 02	.00000E 00	1.14500E-01	.00000E 00
	6.27101E 00	.00000E 00	4.29699E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 12	6.91029E 01	-6.30544E 01	-3.24959E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.47779E 02	.00000E 00	5.14088E 02	.00000E 00	1.14500E-01	.00000E 00
	4.21518E 02	.00000E 00	4.55586E 02	.00000E 00	1.14500E-01	.00000E 00
	6.20546E 00	.00000E 00	4.29825E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 13	8.79952E 01	-4.65544E 01	-1.22929E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.37424E 02	.00000E 00	5.11925E 02	.00000E 00	1.14500E-01	.00000E 00
	4.10956E 02	.00000E 00	4.55013E 02	.00000E 00	1.14500E-01	.00000E 00
	6.27101E 00	.00000E 00	4.28616E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 14	-2.92941E 01	-5.44386E-02	-1.49774E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.34350E 02	.00000E 00	5.25354E 02	.00000E 00	1.14500E-01	.00000E 00
	4.09948E 02	.00000E 00	4.68753E 02	.00000E 00	1.14500E-01	.00000E 00
	4.69778E 00	.00000E 00	4.28500E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 15	-3.06248E 01	4.64456E 01	-1.41075E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.35346E 02	.00000E 00	5.25507E 02	.00000E 00	1.14500E-01	.00000E 00

CH-47A POST TEST MODEL 36 NODES V=340/0.522 DEG=0.-8.7/0

TIME = .00000000

	X / XDOT / U / UDOT / XACCEL	Y / YDOT / V / VDOT / YACCEL	Z / ZDOT / W / WDOT / ZACCEL	PHI / PHIDOT / P / PDOT	THETA / THETADOT / Q / QDOT	PSI / PSIDOT / R / RDOT
	4.10956E 02	.00000E 00	4.68753E 02	.00000E 00	1.14500E-01	.00000E 00
	4.69778E 00	.00000E 00	4.28616E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 16	-4.31154E 01	4.87456E 01	-5.94249E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.44695E 02	.00000E 00	5.26937E 02	.00000E 00	1.14500E-01	.00000E 00
	4.20413E 02	.00000E 00	4.68753E 02	.00000E 00	1.14500E-01	.00000E 00
	4.69778E 00	.00000E 00	4.29699E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 17	-4.31154E 01	-5.44386E-02	-5.94249E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.44695E 02	.00000E 00	5.26937E 02	.00000E 00	1.14500E-01	.00000E 00
	4.20413E 02	.00000E 00	4.68753E 02	.00000E 00	1.14500E-01	.00000E 00
	4.69778E 00	.00000E 00	4.29699E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 18	-4.31154E 01	-4.88544E 01	-5.94249E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.44695E 02	.00000E 00	5.26937E 02	.00000E 00	1.14500E-01	.00000E 00
	4.20413E 02	.00000E 00	4.68753E 02	.00000E 00	1.14500E-01	.00000E 00
	4.69778E 00	.00000E 00	4.29699E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 19	-3.06248E 01	-4.65544E 01	-1.41075E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.35346E 02	.00000E 00	5.25507E 02	.00000E 00	1.14500E-01	.00000E 00
	4.10956E 02	.00000E 00	4.68753E 02	.00000E 00	1.14500E-01	.00000E 00
	4.69778E 00	.00000E 00	4.28616E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 20	-1.49891E 02	-5.44386E-02	-1.68227E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.32238E 02	.00000E 00	5.39163E 02	.00000E 00	1.14500E-01	.00000E 00
	4.09948E 02	.00000E 00	4.82722E 02	.00000E 00	1.14500E-01	.00000E 00
	3.09833E 00	.00000E 00	4.28500E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 21	-1.51222E 02	4.64456E 01	-1.59524E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.33234E 02	.00000E 00	5.39315E 02	.00000E 00	1.14500E-01	.00000E 00
	4.10956E 02	.00000E 00	4.82722E 02	.00000E 00	1.14500E-01	.00000E 00
	3.09833E 00	.00000E 00	4.28616E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 22	-1.63712E 02	4.87456E 01	-7.78735E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.42583E 02	.00000E 00	5.40745E 02	.00000E 00	1.14500E-01	.00000E 00
	4.20413E 02	.00000E 00	4.82722E 02	.00000E 00	1.14500E-01	.00000E 00
	3.09833E 00	.00000E 00	4.29699E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 23	-1.91128E 02	6.29456E 01	-7.72116E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.42659E 02	.00000E 00	5.43884E 02	.00000E 00	1.14500E-01	.00000E 00

CH-47A POST TEST MODEL 36 NODES V=340,0.522 DEG=0.-8.7,0

TIME = .00000000

	X / XDOT / U / UDOT / XACCEL	Y / YDOT / V / VDOT / YACCEL	Z / ZDOT / W / WDOT / ZACCEL	PHI / PHIDOT / P / PDOT	THETA / THETADOT / Q / QDOT	PSI / PSIDOT / R / RDOT
	4.20963E 02	.00000E 00	4.85814E 02	.00000E 00	1.14500E-01	.00000E 00
	2.74435E 00	.00000E 00	4.29761E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 24	-1.63712E 02	-5.44386E-02	-7.78735E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.42583E 02	.00000E 00	5.40745E 02	.00000E 00	1.14500E-01	.00000E 00
	4.20413E 02	.00000E 00	4.82722E 02	.00000E 00	1.14500E-01	.00000E 00
	3.09833E 00	.00000E 00	4.29699E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 25	-1.63712E 02	-4.48544E 01	-7.78735E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.42583E 02	.00000E 00	5.40745E 02	.00000E 00	1.14500E-01	.00000E 00
	4.20413E 02	.00000E 00	4.82722E 02	.00000E 00	1.14500E-01	.00000E 00
	3.09833E 00	.00000E 00	4.29699E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 26	-1.91128E 02	-6.30544E 01	-7.72116E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.42659E 02	.00000E 00	5.43884E 02	.00000E 00	1.14500E-01	.00000E 00
	4.20963E 02	.00000E 00	4.85814E 02	.00000E 00	1.14500E-01	.00000E 00
	2.74435E 00	.00000E 00	4.29761E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 27	-1.51222E 02	-4.65544E 01	-1.59524E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.33234E 02	.00000E 00	5.39315E 02	.00000E 00	1.14500E-01	.00000E 00
	4.10956E 02	.00000E 00	4.82722E 02	.00000E 00	1.14500E-01	.00000E 00
	3.09833E 00	.00000E 00	4.28616E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 28	-1.70908E 02	4.83956E 01	-1.82404E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.30614E 02	.00000E 00	5.41569E 02	.00000E 00	1.14500E-01	.00000E 00
	4.08707E 02	.00000E 00	4.85347E 02	.00000E 00	1.14500E-01	.00000E 00
	2.79784E 00	.00000E 00	4.28358E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 29	-1.70908E 02	-4.85044E 01	-1.82404E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.30614E 02	.00000E 00	5.41569E 02	.00000E 00	1.14500E-01	.00000E 00
	4.08707E 02	.00000E 00	4.85347E 02	.00000E 00	1.14500E-01	.00000E 00
	2.79784E 00	.00000E 00	4.28358E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 30	7.23333E 01	4.87456E 01	-2.05480E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.49147E 02	.00000E 00	5.13718E 02	.00000E 00	1.14500E-01	.00000E 00
	4.22815E 02	.00000E 00	4.55013E 02	.00000E 00	1.14500E-01	.00000E 00
	6.27101E 00	.00000E 00	4.29973E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 31	-2.36066E 02	-5.44386E-02	-2.26524E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.25562E 02	.00000E 00	5.49030E 02	.00000E 00	1.14500E-01	.00000E 00

CH-47A POST TEST MODEL   36 NODES V=340.0,522   DEG=0,-8.7,0

TIME = .00000000

	X / XDOT / U / UDOT / XACCEL	Y / YDOT / V / VDOT / YACCEL	Z / ZDOT / W / WDOT / ZACCEL	PHI / PHIDOT / P / PDOT	THETA / THETADOT / Q / QDOT	PSI / PSIDOT / R / RDOT
	4.04841E 02	.00000E 00	4.93485E 02	.00000E 00	1.14500E-01	.00000E 00
	1.86597E 00	.00000E 00	4.27916E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 32	-2.49902E 02	-5.44386E-02	-1.36076E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.35919E 02	.00000E 00	5.50614E 02	.00000E 00	1.14500E-01	.00000E 00
	4.15318E 02	.00000E 00	4.93485E 02	.00000E 00	1.14500E-01	.00000E 00
	1.86597E 00	.00000E 00	4.29115E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 33	-2.24496E 02	-5.44386E-02	-1.83783E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.30456E 02	.00000E 00	5.47705E 02	.00000E 00	1.14500E-01	.00000E 00
	4.09479E 02	.00000E 00	4.91436E 02	.00000E 00	1.14500E-01	.00000E 00
	2.10064E 00	.00000E 00	4.28447E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 34	-2.04558E 02	-5.44386E-02	-2.77880E 02	.00000E 00	-1.51800E-01	.00000E 00
	3.19682E 02	.00000E 00	5.45422E 02	.00000E 00	1.14500E-01	.00000E 00
	3.98483E 02	.00000E 00	4.90808E 02	.00000E 00	1.14500E-01	.00000E 00
	2.17249E 00	.00000E 00	4.27188E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 35	2.44734E 02	2.09456E 01	-5.73733E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.44930E 02	.00000E 00	4.93978E 02	.00000E 00	1.14500E-01	.00000E 00
	4.15662E 02	.00000E 00	4.36138E 02	.00000E 00	1.14500E-01	.00000E 00
	8.43224E 00	.00000E 00	4.29154E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 36	2.44734E 02	-2.10544E 01	-5.73733E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.44930E 02	.00000E 00	4.93978E 02	.00000E 00	1.14500E-01	.00000E 00
	4.15662E 02	.00000E 00	4.36138E 02	.00000E 00	1.14500E-01	.00000E 00
	8.43224E 00	.00000E 00	4.29154E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			
MASS 37	7.23333E 01	-4.88544E 01	-2.05480E 01	.00000E 00	-1.51800E-01	.00000E 00
	3.49147E 02	.00000E 00	5.13718E 02	.00000E 00	1.14500E-01	.00000E 00
	4.22815E 02	.00000E 00	4.55013E 02	.00000E 00	1.14500E-01	.00000E 00
	6.27101E 00	.00000E 00	4.29973E 02	.00000E 00	.00000E 00	.00000E 00
	1.51218E-01	.00000E 00	9.88500E-01			

IG(IJ),	JG(IJ),	SUMDF(1,IJ),	SUMDF(2,IJ),	SUMDF(3,IJ),	SUMDF(4,IJ),	SUMDF(5,IJ),	SUMDF(6,IJ),	YIELD	PLAST
1	2	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
2	3	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
2	6	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
2	7	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
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2	11	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
2	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
3	4	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
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3	8	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
3	10	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
3	11	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
3	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
6	7	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
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6	15	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
7	15	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
8	9	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
8	10	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
7	16	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
8	16	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
8	30	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
10	18	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
10	11	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
10	17	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
11	12	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
11	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
10	16	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
11	18	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
11	37	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
13	18	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
6	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
13	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	15	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	20	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	21	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
15	16	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
15	21	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
15	22	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
16	17	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
[illegible]	22	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
[illegible]	18	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
[illegible]	22	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
[illegible]	24	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
17	25	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
18	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
18	25	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
19	25	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
19	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	21	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	22	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	23	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	28	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
22	23	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00

22	24	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
22	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
22	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
24	25	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
24	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	26	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
26	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
27	29	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
27	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
27	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	28	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
4	35	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
5	36	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	29	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	33	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
31	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
31	33	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
31	34	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
33	34	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00

IG(IJ),	JG(IJ),	VEE2(1,IJ),	VEE2(2,IJ),	VEE2(3,IJ),	VEE2(4,IJ),	VEE2(5,IJ),	VEE2(6,IJ),	RUPTURE
1	2	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
2	3	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
2	6	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
2	7	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
2	8	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
2	11	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
2	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
3	4	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
3	5	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
3	7	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
3	8	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
3	10	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
3	11	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
3	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
6	7	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
6	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
6	14	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
7	8	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
6	15	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
7	15	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
8	9	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
8	10	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
7	16	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
8	16	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
8	30	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
10	18	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
10	11	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
10	17	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
11	12	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
11	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
10	16	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
11	18	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	
11	37	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	

13	18	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
6	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
13	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	15	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	20	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	21	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
14	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
15	16	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
15	21	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
15	22	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
16	17	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
16	22	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
17	18	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
17	22	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
17	24	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
17	25	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
18	19	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
18	25	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
19	25	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
19	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	21	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	22	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	23	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	28	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
21	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
22	23	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
22	24	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
22	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
22	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
24	25	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
24	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	26	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
26	27	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
27	29	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
27	31	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
27	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	28	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
4	35	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
5	36	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	29	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
20	33	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
31	32	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
31	33	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
31	34	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
33	34	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00

CH-47A POST TEST MODEL 36 NODES V=340,0,522 DEG=0,-8.7,0
TIME= .00000000

I,SC(I,1),SC(I,2),SC(I,3)

3	.00000E 00	.00000E 00	.00000E 00
4	.00000E 00	.00000E 00	.00000E 00
5	.00000E 00	.00000E 00	.00000E 00
8	.00000E 00	.00000E 00	.00000E 00
9	.00000E 00	.00000E 00	.00000E 00
10	.00000E 00	.00000E 00	.00000E 00
11	.00000E 00	.00000E 00	.00000E 00
12	.00000E 00	.00000E 00	.00000E 00
16	.00000E 00	.00000E 00	.00000E 00
17	.00000E 00	.00000E 00	.00000E 00
18	.00000E 00	.00000E 00	.00000E 00
22	.00000E 00	.00000E 00	.00000E 00
23	.00000E 00	.00000E 00	.00000E 00
24	.00000E 00	.00000E 00	.00000E 00
25	.00000E 00	.00000E 00	.00000E 00
26	.00000E 00	.00000E 00	.00000E 00
30	.00000E 00	.00000E 00	.00000E 00
37	.00000E 00	.00000E 00	.00000E 00

***** LINEAR MOMENTUM OF MOVING MASS AGGREGATE*****

SUMMVX	XDOTCG	SUMMVY	YDOTCG	SUMMVZ	ZDOTCG
2.20297E 04	3.40000E 02	.00000E 00	.00000E 00	3.38221E 04	5.22000E 02

***** ENERGY CALCULATIONS *****

	TOTAL ENERGY	KINETIC ENERGY	POTENTIAL ENERGY	STRAIN ENERGY	DAMPING ENERGY	CRUSHING ENERGY
	1.50983E 07	1.25866E 07	2.51179E 06	.00000E 00	.00000E 00	.00000E 00
PERCENT OF TOTAL ENERGY		83.364	16.636	.000	.000	.000

MASS	KENETIC ENERGY	PER CENT	POTENTIAL ENERGY	PER CENT	INTERNAL BEAM IJ I J	STRAIN ENERGY	PER CENT	DAMPING ENERGY	PER CENT	EXTERNAL SPRING 1 K	CRUSHING ENERGY	PER CENT
1	5.57663E 05	4.431	1.84598E 05	7.349								
2	7.98901E 05	6.347	2.06236E 05	8.211								
3	1.18247E 06	9.395	6.26519E 04	2.494								
4	8.27721E 04	.658	6.14611E 03	.245								
5	8.27721E 04	.658	6.14811E 03	.245								
6	1.06315E 05	.845	2.88002E 04	1.147								
7	1.06549E 05	.847	2.68969E 04	1.071								
8	5.37659E 05	4.272	4.46430E 04	1.777								
9	8.03417E 04	.638	5.23183E 03	.208								
10	7.95915E 05	6.324	6.60874E 04	2.631								
11	5.49590E 05	4.366	4.56337E 04	1.817								

```
12  8.03417E 04    .638  5.23183E 03    .208
13  1.06549E 05    .847  2.68969E 04   1.071
14  1.03254E 05    .820  3.07860E 04   1.226
15  7.77263E 04    .618  2.17820E 04    .867
16  7.64926E 05   6.077  8.85075E 04   3.524
17  9.66760E 05   7.681  1.11862E 05   4.453
18  7.38272E 05   5.866  8.54233E 04   3.401
19  7.77263E 04    .618  2.17820E 04    .867
20  2.98610E 05   2.372  9.66858E 04   3.849
21  1.58220E 05   1.257  4.84792E 04   1.930
22  1.96404E 05   1.560  2.88132E 04   1.147
23  1.04914E 05    .834  1.51335E 04    .602
24  6.93537E 05   5.510  1.01750E 05   4.051
25  1.96404E 05   1.560  2.88132E 04   1.147
26  1.04914E 05    .834  1.51335E 04    .602
27  1.58220E 05   1.257  4.84792E 04   1.930
28  4.03131E 05   3.203  1.40998E 05   5.613
29  4.03131E 05   3.203  1.40998E 05   5.613
30  4.84767E 04    .385  1.99315E 03    .079
31  1.66256E 05   1.321  7.13551E 04   2.841
32  2.55451E 05   2.030  6.45001E 04   2.568
33  6.31798E 05   5.020  2.19069E 05   8.722
34  7.22744E 05   5.742  3.87920E 05  15.444
35  9.96826E 04    .792  1.21631E 04    .484
36  9.96826E 04    .792  1.21631E 04    .484
37  4.84767E 04    .385  1.99315E 03    .079
10
BEAM ELT NO=  38I=  14J=  10
RUPTURE AT TIME=   .09990

RUPTURE TIME=****************           38     .140000E 02    .190000E 02

RUPTURE TIME=****************            0     .100000E 03
10
 .1003E 00   .3000E 01
 .1003E 00   .4000E 01
 .1003E 00   .5000E 01
```

OUTPUT AT TIME = 0.104

CH-47A POST TEST MODEL 36 NODES V=340/0/522 DEG=0,-8.7,0

THIS PAGE IS BEST QUALITY PRACTICABLE FROM COPY FURNISHED TO DDC

TIME = .10399973

	X / XDOT / U / UDOT / XACCEL	Y / YDOT / V / VDOT / YACCEL	Z / ZDOT / W / WDOT / ZACCEL	PHI / PHIDOT / P / PDOT	THETA / THETADOT / Q / QDOT	PSI / PSIDOT / R / RDOT

NUMBER OF INT USING DELTMN= 1.0000

MASS 1	2.74733E 02	2.90820E-02	-1.38031E 02	1.21889E-03	-6.89435E-02	-4.66385E-04
	-5.31658E 00	1.35154E 00	-3.06522E 02	-2.04467E-01	3.76849E 00	3.29497E-03
	-2.64206E 01	9.76791E-01	-3.05429E 02	-2.04238E-01	3.76850E 00	-1.30611E-03
	1.01645E 04	-1.47124E 03	-6.41163E 03	-1.16043E 02	-2.47464E 02	4.81275E 00
	2.33509E 01	-3.97303E 00	-1.63530E 01			
MASS 2	2.65923E 02	2.66594E-02	-1.04993E 02	-1.75262E-03	-8.24118E-02	-5.98150E-04
	9.47683E 01	1.21684E 01	-2.73192E 02	-6.14069E-01	1.73752E 00	-4.81087E-02
	7.19504E 01	1.27159E 01	-2.80044E 02	-6.18029E-01	1.73760E 00	-4.49002E-02
	8.82093E 03	1.46751E 03	1.17559E 03	-4.72860E 01	3.29278E 02	3.47025E 00
	2.15930E 01	3.34510E 00	2.70131E 00			
MASS 3	2.53763E 02	7.11350E-01	-9.54478E 00	-8.89441E-03	-6.27350E-02	2.99549E-03
	3.29450E 02	3.23421E 01	-1.72378E 02	-4.46256E-02	2.64857E 00	4.77020E-02
	3.18090E 02	3.30678E 01	-1.92412E 02	-4.16341E-02	2.64804E 00	7.11634E-02
	-4.71743E 03	-1.79188E 03	2.56554E 03	-4.94617E 01	-1.69163E 02	3.22403E 00
	-1.35474E 01	-4.60430E 00	4.46076E 00			
MASS 4	2.74192E 02	2.16742E 01	-2.16737E 01	-1.10283E-02	-5.16706E-02	4.74111E-03
	2.49853E 02	4.14365E 01	-2.84664E 02	-5.01554E-01	5.83721E 00	7.30562E-01
	2.35010E 02	4.35266E 01	-2.96736E 02	-4.63820E-01	5.82883E 00	7.93923E-01
	-4.81118E 03	-4.36987E 03	1.26299E 04	-9.29977E 01	-6.46713E 02	-3.18539E 01
	7.89379E 00	-1.11941E 01	2.91190E 01			
MASS 5	2.74296E 02	-2.03745E 01	-2.12790E 01	-8.60503E-03	-5.15745E-02	1.37041E-03
	2.51880E 02	2.51422E 01	-2.88409E 02	5.16736E-01	6.00637E 00	-6.56360E-01
	2.36711E 02	2.73862E 01	-3.00788E 02	4.82909E-01	6.01181E 00	-6.03785E-01
	4.82614E 03	1.01270E 03	1.25757E 04	1.00281E 02	-6.16143E 02	4.99381E 01
	7.86114E 00	2.62962E 00	2.89272E 01			
MASS 6	1.19155E 02	-1.21247E 00	-9.27445E 01	-7.08307E-03	-1.38921E-01	-2.92991E-03
	2.39095E 02	-2.07847E 01	2.25386E 02	-7.55256E-01	1.61025E-01	-1.40007E-01
	2.68062E 02	-2.14301E 01	1.89950E 02	-7.74644E-01	1.62003E-01	-1.37515E-01
	1.30852E 04	1.17784E 04	8.05781E 03	1.78850E-02	1.02258E-01	8.59785E-02
	3.39717E 01	3.07998E 01	2.08057E 01			
MASS 7	1.18584E 02	4.72430E 01	-8.93898E 01	-7.03406E-02	1.44060E-02	-3.34054E-03
	2.06612E 02	1.26014E 02	-6.79964E 01	4.50306E 00	7.98983E-01	-8.26721E-02
	2.07149E 02	1.30960E 02	-5.59533E 01	4.50425E 00	8.02818E-01	-2.63093E-02
	2.41201E 04	1.70957E 04	9.88424E 03	1.96268E 02	-2.69321E 02	2.65804E 02
	6.23798E 01	4.49283E 01	2.67042E 01			

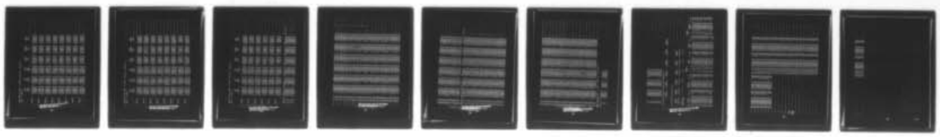
CH-47A POST TEST MODEL   36 NODES   V=340,0,522   DEG=0,-8.7,0

TIME = .10399973

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 8	1.10481E 02	5.55904E 01	-8.09652E 00	6.74628E-02	1.08662E-02	-1.72970E-04
	2.99870E 02	-5.89736E 01	-1.42047E 02	1.05428E 00	1.45079E 00	-1.00364E 00
	3.01406E 02	-6.81431E 01	-1.34493E 02	1.06519E 00	1.37984E 00	-1.09909E 00
	-7.28966E 03	-9.17463E 03	8.34741E 03	-7.22734E 02	-7.82628E 02	5.95115E 01
	-1.95599E 01	-2.42555E 01	2.03599E 01			
MASS 9	8.50902E 01	5.02255E 01	-1.64158E 01	2.42369E 00	-3.03829E-01	-2.86778E 00
	4.04364E 01	-2.74780E 02	-2.15809E 02	1.94041E 01	4.93254E 01	9.81255E 00
	-3.08134E 01	-3.49906E 02	-1.81420E 01	2.23397E 01	-3.09920E 01	-3.94988E 01
	1.33741E 04	-1.38010E 03	8.49436E 03	1.09194E 03	7.22884E 02	1.87122E 02
	2.99176E-01	6.27680E-01	-7.18687E-01			
MASS 10	1.09771E 02	-2.57051E 00	-6.53552E 00	5.80109E-03	-1.20901E-01	1.22077E-03
	3.44852E 02	8.33693E 00	-1.78777E 02	-3.83513E 00	2.78721E 00	-6.77334E-03
	3.20783E 02	6.64504E 00	-2.19107E 02	-3.83596E 00	2.78712E 00	-2.28918E-02
	-1.33164E 04	4.47670E 03	3.75469E 03	9.01270E 02	2.12123E 02	-4.87727E 01
	-3.60800E 01	9.40124E 00	7.34493E 00			
MASS 11	1.09305E 02	-5.13297E 01	-7.05670E 00	2.00194E-02	1.04049E-02	6.27877E-03
	3.12798E 02	2.73196E 00	-2.00694E 00	-3.66660E 00	4.11185E-02	1.55550E 00
	3.12813E 02	7.92650E-01	1.23201E 00	-3.68279E 00	7.22386E-02	1.55428E 00
	1.31803E 04	2.46031E 03	8.40002E 03	-1.54657E 02	-2.66691E 02	-7.79337E 00
	3.41429E 01	7.64519E 00	2.16956E 01			
MASS 12	8.56106E 01	-4.85730E 01	-1.91673E 01	-2.40437E 00	-1.64717E-01	2.74658E 00
	4.96498E 01	3.17548E 02	-2.79621E 02	-2.51918E 01	5.02986E 01	-1.42661E 01
	2.94892E 01	4.24979E 02	3.61311E 00	-2.75310E 01	-2.77778E 01	4.42311E 01
	1.89609E 04	-1.65978E 03	1.05991E 04	-1.09595E 03	9.97601E 02	-2.06689E 02
	1.63973E-01	-6.63133E-01	-7.30320E-01			
MASS 13	1.18087E 02	-4.49726E 01	-8.63603E 01	-2.08356E-02	7.11253E-03	1.98736E-02
	2.22898E 02	-8.37634E 01	2.92183E 02	6.10080E 00	3.76249E 00	1.89489E 00
	2.19106E 02	-9.42772E 01	2.91848E 02	6.08733E 00	3.72220E 00	1.97282E 00
	2.03054E 04	-1.89035E 04	-4.97242E 03	-5.47299E 02	4.74401E 01	-2.10861E 02
	5.59007E 01	-5.24554E 01	-1.64815E 01			
MASS 14	6.73337E-02	-2.85102E-01	-9.83428E 01	-4.44871E-02	-1.38219E-01	-1.60347E-03
	2.17603E 02	-6.09371E 01	4.70206E 02	-1.96043E 00	2.02334E-01	-1.05377E-01
	2.80409E 02	-7.99063E 01	4.32602E 02	-1.97495E 00	2.06775E-01	-9.52710E-02
	1.05792E 04	-6.90484E 02	-1.40134E 02	1.84981E 01	2.42250E 00	-4.95552E-01
	2.76193E 01	3.55354E-01	-1.04418E-01			
MASS 15	-8.43618E-01	4.64643E 01	-9.14280E 01	1.13238E-02	-6.60063E-02	-5.42737E-04
	2.15449E 02	-2.17170E 01	2.83820E 02	1.57359E 00	3.31682E 00	1.21014E-01
	2.33712E 02	-1.85528E 01	2.69217E 02	1.58156E 00	3.31798E 00	8.31794E-02
	1.52202E 04	5.26697E 03	-1.55356E 03	3.37942E 02	-5.29507E 01	1.22114E 02
	4.17488E 01	1.25923E 01	-6.10973E 00			

AD-A062 643 BOEING VERTOL CO PHILADELPHIA PA F/G 1/3
SIMULATION CORRELATION, AND ANALYSIS OF THE STRUCTURAL RESPONSE--ETC(U)
AUG 78 Y V BADRINATH DAAJ02-76-C-0015
UNCLASSIFIED D210-11354-1 USARTL-TR-78-24 NL

4 OF 4
ADA
062643



END
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CH-47A POST TEST MODEL 36 MODES V=340,0,522 DEG=0,-8.7,0

TIME = .10399973

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 16	-9.56671E 00	4.75876E 01	-9.27489E 00	-3.40404E-02	-7.43176E-02	-3.35977E-03
	3.11560E 02	-6.62633E 01	2.97598E 02	-3.57677E 00	2.38269E-01	-5.74991E-01
	3.33017E 02	-7.44912E 01	2.71249E 02	-3.61947E 00	2.57624E-01	-5.64965E-01
	1.22814E 04	3.84309E 03	-3.96127E 03	-1.87518E 01	4.14252E 02	5.09074E 01
	3.18890E 01	1.20122E 01	-9.78616E 00			
MASS 17	-1.03689E 01	-1.16179E 00	-7.41071E 00	-2.04898E-02	-1.21665E-01	-2.49341E-02
	3.76448E 02	-3.79832E 01	4.66548E 02	-1.35629E-01	1.02300E 00	-1.07707E 00
	4.31111E 02	-3.71300E 01	4.16638E 02	-2.66346E-01	1.04469E 00	-1.04792E 00
	-5.76016E 03	1.13761E 03	-5.89517E 03	1.92253E 01	2.84924E 01	3.96940E 01
	-1.38959E 01	2.06426E 00	-1.64136E 01			
MASS 18	-1.08772E 01	-4.99320E 01	-7.06603E 00	-1.20435E-02	-8.54547E-02	7.50025E-03
	3.22182E 02	-1.90190E 01	3.27859E 02	2.96929E 00	1.86904E 00	1.53609E 00
	3.48838E 02	-2.50362E 01	2.98897E 02	3.10040E 00	1.85045E 00	1.55288E 00
	-1.79640E 03	-1.51238E 03	-1.16737E 04	2.74358E 02	3.64913E 02	2.24408E 01
	-3.12027E 00	-4.91548E 00	-3.21161E 01			
MASS 19	-1.44791E 00	-4.64981E 01	-8.91019E 01	6.02056E-02	-7.11912E-02	4.29400E-03
	2.35066E 02	-7.22210E 01	3.24255E 02	5.29401E 00	4.81106E-01	-3.05587E-01
	2.57224E 02	-5.46411E 01	3.10586E 02	5.27228E 00	4.61898E-01	-3.33208E-01
	2.19565E 04	-5.13982E 03	-4.61372E 03	-8.21511E 01	-1.99345E 02	-6.92677E 01
	5.72065E 01	-1.77798E 01	-1.30068E 01			
MASS 20	-1.20791E 02	4.15634E-01	-1.11901E 02	-5.51021E-03	-1.51459E-01	-2.72920E-03
	2.18936E 02	2.55910E 01	4.70388E 02	-2.96892E-01	1.30661E 00	-4.52919E-02
	2.87332E 02	2.38079E 01	4.32118E 02	-3.03725E-01	1.30684E 00	-3.75731E-02
	2.85558E 03	-2.00781E 03	-1.93591E 02	-2.77496E 01	1.64576E 01	4.43850E 00
	8.86316E 00	-4.88954E 00	-1.49305E 00			
MASS 21	-1.21538E 02	4.72883E 01	-1.04072E 02	-1.05484E-02	-1.28908E-01	-4.47286E-03
	1.96765E 02	1.71304E 01	4.87378E 02	-8.07581E-01	4.83140E-01	4.45184E-01
	2.57707E 02	1.31780E 01	4.58217E 02	-7.50354E-01	4.78462E-01	4.46564E-01
	1.17449E 03	-7.63223E 03	-1.13956E 04	-4.91093E 01	-6.91223E 01	-5.28744E 00
	3.59545E 00	-1.85837E 01	-2.98674E 01			
MASS 22	-1.31005E 02	4.89031E 01	-2.19909E 01	-7.10238E-03	-1.25465E-01	-1.44171E-02
	3.22803E 02	3.94519E 01	5.06580E 02	-7.56833E-01	1.09995E 00	-1.22273E 00
	3.83059E 02	4.08170E 01	4.62581E 02	-9.09839E-01	1.10853E 00	-1.20527E 00
	1.07527E 04	9.37849E 03	-1.32830E 04	-2.99278E 01	3.92416E 02	-2.08884E 01
	2.93126E 01	2.41909E 01	-3.56081E 01			
MASS 23	-1.60132E 02	6.29297E 01	-2.13339E 01	1.54832E-02	-1.94943E-01	1.85006E-02
	6.53747E 01	3.75022E 01	3.92742E 02	2.32468E 00	-6.97469E 00	1.14834E 00
	1.41516E 02	4.70728E 01	3.71699E 02	2.14348E 00	-6.93130E 00	1.23437E 00
	-4.29072E 03	5.78420E 04	-5.21256E 04	-3.49422E 03	5.11167E 02	1.34726E 01
	-1.79527E 01	1.47846E 02	-1.32224E 02			

CH-47A POST TEST MODEL   36 NODES V=340,0,522   DEG=0,-8.7,0

TIME = .10399973

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 24	-1.31967E 02	1.67426E-01	-2.12079E 01	-5.15697E-03	-1.27571E-01	-1.78693E-02
	3.91970E 02	4.60255E 01	5.84509E 02	-4.42692E-01	3.35356E-01	-8.11355E-01
	4.62272E 02	5.02882E 01	5.30270E 02	-5.45917E-01	3.39501E-01	-8.03022E-01
	2.74412E 03	3.35059E 03	-8.42581E 03	-1.25633E 01	2.58556E 00	3.05548E 01
	7.68014E 00	8.46856E 00	-2.23062E 01			
MASS 25	-1.32264E 02	-4.85578E 01	-2.13347E 01	1.08695E-03	-1.33804E-01	-5.51049E-03
	3.27435E 02	5.04727E 01	5.46355E 02	7.31607E-01	8.04724E-01	-1.69016E-01
	3.97114E 02	5.28174E 01	4.97771E 02	7.09058E-01	8.04531E-01	-1.68380E-01
	1.89843E 03	-1.29412E 03	-1.26615E 04	4.96030E 01	4.35331E 02	6.14495E 00
	5.97875E 00	-4.44026E 00	-3.35324E 01			
MASS 26	-1.61091E 02	-6.25516E 01	-2.09162E 01	6.35194E-03	-2.10200E-01	-5.72400E-03
	8.88878E 01	-6.16043E 00	3.49327E 02	8.38247E-01	-7.92059E 00	1.39107E-01
	1.58898E 02	2.63566E 00	3.23281E 02	3.74682E-01	-7.95698E 00	1.86246E-01
	-2.03358E 04	5.14640E 04	-7.26199E 04	-5.16835E 03	-6.85375E 01	5.22240E 00
	-5.93111E 01	1.32677E 02	-1.84863E 02			
MASS 27	-1.22032E 02	-4.64184E 01	-1.03312E 02	9.61361E-03	-1.42269E-01	6.40996E-03
	1.95279E 02	1.01256E 01	5.08119E 02	1.45690E 00	3.64527E-01	-1.52861E 00
	2.65413E 02	1.34428E 01	4.75179E 02	1.24016E 00	3.49968E-01	-1.51661E 00
	7.21934E 03	7.55747E 03	-2.07194E 04	5.98812E 01	2.70792E 01	-1.93527E 02
	1.91866E 01	1.70094E 01	-5.38747E 01			
MASS 28	-1.41631E 02	4.89524E 01	-1.26536E 02	-1.82849E-02	-1.29795E-01	-2.81987E-03
	2.01628E 02	6.56708E 00	4.66635E 02	2.47051E-01	-6.84920E-01	1.80964E 00
	2.60310E 02	-8.48557E-01	4.36673E 02	4.81276E-01	-7.17612E-01	1.78160E 00
	-1.05884E 04	-9.69114E 03	-1.01038E 03	1.03470E 02	-2.23013E 02	-9.93075E 01
	-2.82391E 01	-2.44496E 01	-2.13469E 00			
MASS 29	-1.41819E 02	-4.81744E 01	-1.26041E 02	6.21469E-03	-1.44018E-01	2.76154E-03
	2.00358E 02	3.62056E 01	4.88731E 02	-7.54654E-01	-1.29087E 00	-2.35916E 00
	2.68525E 02	3.84785E 01	4.54671E 02	-1.09325E 00	-1.30535E 00	-2.32667E 00
	-9.21828E 03	5.55255E 03	-3.46293E 03	-1.35979E 02	-4.34641E 01	-8.96077E 01
	-2.51872E 01	1.40540E 01	-8.17222E 00			
MASS 30	1.05453E 02	4.87454E 01	-8.17992E 01	.00000E 00	-1.30849E 00	.00000E 00
	3.18115E 02	-1.24748E-03	-6.05909E 02	.00000E 00	-1.14615E 01	.00000E 00
	-5.02696E 02	-1.24748E-03	-4.64348E 02	.00000E 00	-1.14615E 01	.00000E 00
	-4.94932E 03	.00000E 00	5.86173E 03	.00000E 00	.00000E 00	.00000E 00
	9.65796E-01	.00000E 00	2.59304E-01			
MASS 31	-2.07643E 02	3.98966E-01	-1.68840E 02	-6.81132E-03	-1.36988E-01	-6.30173E-03
	1.33810E 02	4.54560E 00	5.87872E 02	-1.96414E-01	6.52673E-01	-5.50144E-02
	2.12805E 02	1.54637E 00	5.64120E 02	-2.03926E-01	6.53021E-01	-5.00525E-02
	-6.39192E 03	-2.30299E 03	7.13555E 03	1.86572E 01	1.27977E 02	5.60777E 01
	-1.56048E 01	-5.69586E 00	1.81250E 01			

CH-47A POST TEST MODEL   36 NODES V=340,0,522   DEG=0,-8.7,0

TIME = .10399973

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 32	-2.19374E 02	1.03917E 00	-7.78342E 01	-6.80610E-03	-1.27270E-01	-6.37453E-03
	2.49656E 02	1.53645E 01	6.44226E 02	-2.39444E-01	1.00712E 00	-2.40625E-01
	3.29303E 02	1.28217E 01	6.07442E 02	-2.69987E-01	1.00872E 00	-2.31819E-01
	7.08656E 03	-3.73747E 03	2.77076E 03	7.07428E 01	2.35968E 01	-2.80976E 00
	1.99541E 01	-9.45545E 00	6.30861E 00			
MASS 33	-1.95480E 02	6.01013E-01	-1.26281E 02	-6.92956E-03	-1.37575E-01	-6.00392E-03
	1.68240E 02	1.22665E 01	5.74534E 02	-2.18413E-01	7.08656E-01	1.14748E-01
	2.45367E 02	9.49231E 00	5.46122E 02	-2.02676E-01	7.07853E-01	1.18573E-01
	-6.86671E 03	-2.00196E 03	7.91816E 03	-6.56967E 00	-6.15378E 01	5.38034E 01
	-1.67908E 01	-4.82429E 00	2.00584E 01			
MASS 34	-1.76808E 02	-1.65876E-01	-2.20635E 02	-6.74344E-03	-1.38577E-01	-6.21255E-03
	9.36744E 01	-4.64354E 00	5.59765E 02	-1.55860E-01	7.37923E-01	-1.48848E-02
	1.70126E 02	-7.71264E 00	5.41416E 02	-1.57916E-01	7.38001E-01	-9.76633E-03
	-7.52803E 03	-5.18098E 02	8.01726E 03	9.93369E 00	9.09341E 00	5.68636E 01
	-1.84677E 01	-1.12503E 00	2.04480E 01			
MASS 35	2.74989E 02	2.12150E 01	-4.41562E 01	-3.33063E-02	-4.20016E-02	1.20865E-02
	9.65848E 01	1.20567E 01	-2.89761E 02	-2.15351E 00	2.82384E 00	1.71844E 00
	8.44709E 01	2.06582E 01	-2.93042E 02	-2.08136E 00	2.76509E 00	1.81001E 00
	2.41730E 04	-2.31063E 03	1.26244E 04	4.65487E 02	6.84239E 02	1.10150E 02
	6.04283E 01	-7.17009E 00	3.19893E 01			
MASS 36	2.75077E 02	-2.05938E 01	-4.37657E 01	-5.25808E-03	-4.15028E-02	-1.31997E-04
	9.82811E 01	4.32312E 01	-2.94282E 02	1.01086E 00	2.32337E 00	-1.36580E 00
	8.59804E 01	4.48111E 01	-2.97875E 02	9.54196E-01	2.33049E 00	-1.35239E 00
	2.41376E 04	5.26884E 03	1.24351E 04	-2.98822E 02	6.95572E 02	-1.53274E 02
	6.08912E 01	1.40849E 01	3.18070E 01			
MASS 37	1.05448E 02	-4.88543E 01	-8.18220E 01	.00000E 00	-1.30893E 00	.00000E 00
	3.18072E 02	1.20143E-03	-6.06143E 02	.00000E 00	-1.14659E 01	.00000E 00
	-5.03137E 02	1.20143E-03	-4.64147E 02	.00000E 00	-1.14659E 01	.00000E 00
	-4.94901E 03	.00000E 00	5.86884E 03	.00000E 00	.00000E 00	.00000E 00
	9.65910E-01	.00000E 00	2.58880E-01			

IG(IJ)	JG(IJ)	SUMDF(1,IJ)	SUMDF(2,IJ)	SUMDF(3,IJ)	SUMDF(4,IJ)	SUMDF(5,IJ)	SUMDF(6,IJ)	YIELD	PLAST
1	2	-2.64425E 04	-4.78828E 03	-1.54358E 04	1.28646E 04	-8.17782E 05	2.03070E 05		
2	3	-1.78673E 04	6.17331E 03	7.60911E 04	4.74016E 04	5.52892E 06	-1.80581E 05		
2	6	-3.89624E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
2	7	-5.11701E 04	-1.01334E 01	8.48790E 03	4.70512E 01	1.64116E 05	2.43632E 02		
2	8	6.39716E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		*
2	11	6.39716E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		*
2	13	-3.72899E 04	-7.08487E 01	1.26528E 04	-3.88417E 00	3.46146E 05	7.47062E 03		
3	4	-1.54308E 03	1.10866E 04	-1.18630E 04	1.33341E 05	1.74681E 05	6.35854E 04		
3	5	-1.58148E 03	-1.13359E 04	-1.15626E 04	-1.68197E 05	1.27842E 05	-7.48048E 04		

3	7	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		*
3	8	6.07506E 04	-6.31028E 02	2.27997E 03	-4.74257E 01	-1.51665E 06	5.23511E 04		*
3	10	-4.60984E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
3	11	8.40301E 04	2.29814E 02	6.81074E 03	-5.17751E 01	-1.09259E 06	-1.75292E 04		
3	13	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		*
6	7	7.28797E 03	-6.06684E 01	-1.33262E 03	1.96408E 03	-1.71869E 04	1.00330E 03		*
6	13	-1.07229E 03	3.80180E 01	-4.59236E 03	-1.22356E 03	-1.23028E 05	-2.37948E 02		*
6	14	-4.82309E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
7	8	-1.54305E 04	1.40296E 03	-2.93939E 03	3.51404E 02	-1.76220E 05	-5.69085E 04		*
6	15	1.10150E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
7	15	-6.38396E 04	-5.11955E 03	-6.42134E 03	-4.05858E 01	-1.08790E 06	2.94384E 05		
8	9	4.40580E 04	4.98073E 03	-6.81582E 03	-2.40000E 04	-1.51053E 04	3.11489E 03		*
8	10	-1.69044E 03	-1.88328E 03	1.30767E 03	2.46963E 04	4.97180E 05	2.56029E 04		*
7	16	7.33564E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		*
8	16	7.52672E 04	-1.53613E 03	-2.19682E 04	1.02366E 02	-3.03346E 06	9.39548E 04	*	*
8	30	-6.40000E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		*
10	18	8.16955E 03	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
10	11	-2.03228E 04	-3.78009E 03	5.02668E 03	-3.36845E 05	5.24872E 05	9.43990E 04		*
10	17	8.05715E 03	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
11	12	-5.31985E 03	-4.98073E 03	-6.81582E 03	2.40000E 04	-1.51053E 04	-8.11489E 03		*
11	13	-3.15181E 04	-7.97875E 02	-2.93088E 03	-7.44377E 02	-6.83694E 04	3.25616E 04		*
10	16	-5.03060E 03	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
11	18	4.49167E 04	4.61077E 02	-3.24246E 04	3.07959E 01	-3.57019E 06	-3.05842E 04		*
11	37	-6.40000E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		*
13	18	7.33564E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		*
6	19	-9.56293E 03	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
13	19	-4.89671E 04	-7.71332E 01	-6.72329E 03	-4.05647E 01	-1.07576E 06	1.40091E 05		
14	15	-2.90523E 03	6.51677E 01	-9.44388E 02	1.21047E 03	-3.67268E 04	-2.12278E 03	*	*
14	19	-4.44690E 03	-1.04085E 02	2.60648E 02	-1.06989E 03	2.05466E 04	3.26779E 03	*	*
14	20	-2.32914E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
14	21	-1.28350E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
14	27	-2.01568E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
15	16	-3.06708E 03	5.28759E 02	3.86154E 03	-1.21643E 02	2.10937E 05	-2.14686E 04		
15	21	-7.32219E 04	2.75414E 03	4.90531E 03	1.11181E 01	-2.37520E 05	-1.34023E 05		
15	22	1.45647E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
16	17	-3.56463E 03	3.21780E 02	1.67754E 04	2.29827E 04	6.56031E 05	-3.68412E 04		
16	22	2.50275E 04	5.76285E 01	1.10728E 04	-2.59276E 01	-1.07627E 06	1.76843E 03		
17	18	-1.12264E 04	-3.51962E 02	-1.40455E 04	-1.76154E 04	-8.61116E 04	5.08088E 04		
17	22	2.04828E 03	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
17	26	1.98937E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
17	25	1.01070E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
18	19	5.13176E 03	-5.47731E 02	3.06176E 01	2.01894E 02	-5.24772E 04	2.45753E 04	*	*
18	25	5.28295E 04	2.83626E 02	1.90301E 04	-1.20202E 01	-4.89035E 05	-1.13479E 04		
19	25	-6.40307E 02	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
19	27	-6.62920E 04	2.57457E 03	7.63122E 03	2.52077E 01	-1.41117E 05	-1.81199E 05		
20	21	1.01085E 04	-3.84098E 01	-1.28002E 03	3.71152E 02	-2.77123E 04	6.25274E 02		
20	27	1.52755E 04	-1.16174E 01	-1.50723E 02	-1.24877E 02	4.41893E 03	7.92715E 02		
20	31	-1.67267E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
21	22	3.12218E 03	-1.79107E 02	2.71847E 03	-4.15038E 02	1.10924E 05	7.17165E 03		
21	23	-3.72461E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
21	28	-3.28824E 04	7.48208E 03	-1.16987E 04	4.16746E 04	-1.14093E 05	-7.31908E 03		
21	31	-2.57655E 04	4.00933E 01	3.49309E 02	6.55732E-01	1.11870E 05	-2.48555E 03		
21	32	-2.15989E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
22	23	8.69509E 03	1.29259E 03	-3.10854E 02	-4.25816E 04	-9.04402E 03	6.29808E 04		
22	26	-2.19647E 04	-4.44075E 02	1.63349E 04	5.44429E 03	4.34585E 05	6.34703E 03		
22	31	1.80877E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00		
22	32	2.59451E 04	-1.10304E 02	-5.57342E 03	-3.33622E 00	-1.79184E 05	8.76757E 03		

24	25	-3.34277E 04	1.52346E 03	-8.45077E 03	1.58475E 04	-1.73148E 04	-2.13574E 04
24	32	1.10602E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	26	6.75175E 03	-2.28640E 03	1.25338E 02	4.28015E 04	6.10863E 03	-2.53261E 04
25	27	2.94684E 03	2.07646E 02	-1.11672E 03	-5.10755E 02	-5.77456E 04	-9.57724E 03
25	31	2.78928E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
25	32	5.28024E 04	-1.01754E 02	3.22828E 03	9.63314E 00	6.78038E 04	6.94693E 03
26	27	-4.02882E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
27	29	-3.20407E 04	-1.33041E 04	-1.16635E 04	4.94517E 04	-1.16977E 05	1.98106E 05
27	31	-2.11719E 04	-2.14674E 01	2.93948E 03	1.10995E 01	1.84888E 05	9.88633E 02
27	32	-3.40154E 04	.00000E 00	.00000E 00	.00000E 00	.00000E 00	.00000E 00
30	28	3.16400E 04	-3.41855E 03	-3.29802E 03	1.03014E 05	-6.15212E 04	1.51757E 05
4	35	6.78269E 03	1.49897E 03	-1.21372E 04	-1.41507E 04	-1.18046E 05	-6.11703E 04
5	36	6.68986E 03	-3.04700E 03	-1.23337E 04	3.76544E 03	-1.18952E 05	4.13837E 04
30	29	2.88998E 04	1.55058E 03	1.30779E 03	-5.43593E 04	2.01388E 05	-2.76117E 04
30	33	-3.42730E 04	-1.32811E 02	-8.05712E 02	8.46221E 02	-1.87892E 04	6.70992E 03
31	32	5.67874E 04	-4.14138E 03	-1.04772E 04	-2.05332E 03	-1.71356E 05	1.93117E 05
31	33	-2.97031E 04	5.89147E 03	3.55964E 00	.00000E 00	-4.40921E 01	-2.49546E 04
31	34	3.25802E 04	1.40463E 03	1.35374E 04	-5.91589E 03	-3.31031E 04	-1.22238E 04
33	34	2.19417E 03	1.37187E 02	1.14045E 03	5.06902E 03	2.55001E 04	-2.35756E 03

IG(IJ),	JG(IJ),	VEE2(1,IJ),	VEE2(2,IJ),	VEE2(3,IJ),	VEE2(4,IJ),	VEE2(5,IJ),	VEE2(6,IJ),	RUPTURE
1	2	-9.98923E-03	3.43876E-02	1.78208E-01	4.00542E-04	-1.34865E-02	2.95457E-03	
2	3	-8.35974E-02	5.08884E-01	1.60515E 00	3.97331E-03	1.96774E-02	6.72531E-03	
2	6	-7.73817E-01	-1.36914E 00	-1.35554E 01	5.31991E-03	-5.64799E-02	3.31096E-03	
2	7	-5.47110E-01	-1.17682E 00	8.25643E 00	9.41023E-02	-7.11812E-02	-9.44888E-03	
2	8	1.55390E 00	-3.11142E 00	6.73795E 00	5.55363E-02	-5.14563E-02	-1.04600E-02	*
2	11	1.55256E 00	1.71236E 00	6.95593E 00	-7.70151E-02	-4.26317E-02	2.52267E-02	*
2	13	-3.98728E-01	-7.28744E-01	1.11780E 01	-7.76834E-03	-9.16138E-02	2.21756E-02	
3	4	-1.93443E-03	1.29786E-01	-2.24469E-01	5.23440E-03	9.12763E-03	4.35253E-03	
3	5	-1.98257E-03	-1.35590E-01	-2.01155E-01	-6.60267E-03	7.87739E-03	-4.61722E-03	
3	7	-1.55163E 00	-2.79432E-01	3.73317E 00	1.22038E-02	-1.83965E-02	8.34569E-03	*
3	8	3.31518E-01	-6.79705E 00	4.90756E 00	-4.74257E-02	-9.53208E-02	-5.35394E-03	
3	10	-1.06100E 00	-2.95729E 00	-6.06071E 00	-1.47744E-02	-5.79480E-02	5.68738E-03	
3	11	4.58555E-01	3.02031E 00	5.07932E 00	-5.17751E-02	-5.87813E-02	8.36073E-03	
3	13	-1.55147E 00	2.32927E-01	3.72289E 00	-1.00119E-02	-1.92971E-02	-6.87924E-03	*
6	7	1.46008E-01	-4.93057E-01	-2.47941E 00	1.15532E-01	7.61151E-02	-8.88982E-03	*
6	13	-2.14823E-02	4.98058E-01	-2.05003E 00	-7.19715E-02	-7.61670E-02	1.35416E-02	*
6	14	-7.76352E-01	5.00412E-01	-1.09495E 01	3.72193E-02	6.69715E-04	-1.33300E-03	
7	8	-4.67422E-02	8.74329E 00	4.08396E-01	8.36633E-03	-1.26261E-01	2.25075E-02	*
6	15	1.35327E-01	-1.08343E 00	9.51100E 00	9.01942E-03	-7.47381E-02	1.35319E-03	
7	15	-5.51149E-01	-9.10712E-01	3.83279E 00	-8.11716E-02	-8.10680E-02	-1.47533E-03	
8	9	7.28231E-03	1.10011E 01	-4.30948E 00	-7.02375E-01	6.80648E-01	3.45478E-01	*
8	10	-2.90983E-03	-6.98182E-01	-3.52265E-01	9.64694E-03	4.00451E-02	-1.58630E-02	*
7	16	1.10354E 00	3.22425E-01	-3.60435E-01	7.74968E-03	7.55095E-03	-7.36866E-03	*
8	16	3.22178E-01	-8.17233E 00	1.93675E 00	1.02366E-01	-8.39041E-02	3.69018E-03	
8	30	-8.28069E-03	-2.54804E-04	2.06259E-02	-7.76137E-09	-1.13899E-03	5.09691E-06	*
10	18	7.16227E-02	-1.50322E 00	1.43028E 01	2.33090E-03	-3.93311E-02	4.42244E-03	
10	11	-3.49826E-02	-5.84262E-01	-1.71918E-01	-1.31580E-01	1.72949E-02	1.61801E-03	
10	17	1.53470E-01	1.63427E 00	-1.36096E 01	2.95640E-02	-2.04256E-03	2.64040E-02	
11	12	-8.79315E-04	-1.10126E 01	-5.70354E 00	8.17588E-01	6.65095E-01	-3.59883E-01	*
11	13	-9.54745E-02	-4.88914E 00	-5.95751E 00	-1.77234E-02	1.26185E-01	-1.08256E-02	*
10	16	-6.20633E-02	-1.93065E 00	1.13724E 01	5.51317E-02	-2.77632E-02	-6.65640E-03	
11	18	1.92264E-01	2.12651E 00	1.30392E 00	3.07959E-02	-9.47811E-02	-6.53865E-03	
11	32	-8.29171E-03	1.97354E-04	2.06308E-02	8.60268E-10	-1.13896E-03	-6.78930E-06	*
13	18	1.10001E 00	2.15765E-01	-2.56488E-01	-1.21812E-02	6.26747E-03	1.02103E-02	*
6	19	-1.17488E-01	-2.37748E-01	1.12323E 01	-8.76379E-02	-3.89770E-02	9.28440E-03	
13	19	-4.22750E-01	9.25379E-01	3.57479E 00	-8.11293E-02	-7.75762E-02	1.56295E-02	
14	15	-5.82036E-02	2.39389E-02	2.72610E-01	7.12040E-02	-5.59555E-02	-1.17688E-02	

14	18	-8.90894E-02	-9.76049E-02	-5.89230E-01	-6.29328E-02	7.63121E-02	1.62947E-02
14	20	-3.81158E-01	3.63194E-01	-3.24238E 00	-3.88218E-02	-1.32306E-02	1.06019E-03
14	21	-1.52344E-01	-5.61979E-01	4.41145E 00	-2.81302E-02	-2.06376E-02	-8.55757E-04
14	27	-2.39250E-01	4.53356E-01	1.03740E 00	-4.95462E-02	2.35054E-02	1.11956E-02
15	16	-9.29080E-03	3.28658E 00	2.44686E-01	-2.89426E-03	4.56148E-02	8.27742E-03
15	21	-6.42692E-01	7.05820E-01	4.66451E 00	2.22362E-02	-6.29580E-02	3.98547E-03
15	22	1.94684E-01	-8.87518E-01	-5.80167E 00	7.38026E-03	5.98518E-02	-2.19375E-02
16	17	-8.16115E-03	-4.97531E-01	2.46186E-01	4.69034E-02	1.17288E-02	-2.25461E-02
16	22	1.08910E-01	1.03168E 00	3.63115E 00	-2.59276E-02	-5.08876E-02	1.19245E-02
17	18	-2.57026E-02	7.43914E-01	-7.43373E-01	-3.59497E-02	1.21985E-02	3.28384E-02
17	22	2.56327E-02	1.91362E 00	1.27898E 00	-1.51423E-02	-1.72090E-03	1.02863E-02
17	24	3.85246E-01	-1.72430E 00	-1.02667E 00	-1.62213E-02	-6.01326E-03	-6.87536E-03
17	25	1.26481E-01	1.70593E 00	-2.08768E-01	-1.78001E-02	2.03276E-02	1.91837E-02
18	19	1.55451E-02	-2.41889E 00	2.05868E 00	4.80699E-03	-7.18460E-02	1.47999E-02
18	25	2.29893E-01	2.33078E 00	3.82941E 00	-1.20202E-02	-4.79291E-02	1.29915E-02
19	25	-8.55889E-03	-5.50033E 00	-6.76055E 00	4.55067E-02	6.15912E-02	-4.18282E-02
19	27	-5.81866E-01	2.59736E-01	5.62244E 00	5.04154E-02	-7.11542E-02	-2.83290E-03
20	21	2.02513E-01	-3.16961E-01	-7.20044E-01	2.18325E-02	5.37968E-03	-5.83074E-03
20	27	3.06030E-01	1.96195E-01	-4.64081E-01	-7.34570E-03	1.66617E-02	1.05489E-02
20	31	-1.91948E-01	-1.57699E-02	-1.47114E 00	3.12084E-03	1.44885E-02	2.33186E-03
21	22	9.45772E-03	-1.15564E 00	1.59936E 00	-9.83186E-03	-2.13831E-03	-3.80875E-03
21	23	-3.24048E-01	2.03305E 00	3.13124E-01	3.71541E-04	4.07498E-02	6.42903E-02
21	28	-6.16549E-02	1.59146E-01	-1.00106E-01	4.57962E-03	1.49738E-03	6.05302E-03
21	31	-1.79538E-01	4.06824E-01	-4.11197E-01	1.31146E-03	8.76503E-03	-1.51846E-03
21	32	-2.25804E-01	7.74958E-01	5.75895E-02	-4.26867E-03	5.99263E-05	-4.68338E-04
22	23	3.28117E-03	1.40647E-01	4.40502E-02	-6.00032E-03	-6.25296E-03	6.37861E-03
22	24	-4.83804E-02	-1.58743E-01	4.63157E-01	2.12668E-03	1.49727E-03	-3.49936E-03
22	31	2.23949E-01	-1.22329E-02	-5.96260E-01	-3.74234E-03	1.08590E-02	8.19908E-03
22	32	9.11026E-02	2.45982E-02	-2.67260E-01	-3.33622E-03	2.22973E-03	7.19493E-03
24	25	-7.36294E-02	5.52514E-01	-4.50103E-01	6.19042E-03	7.85211E-03	1.23295E-02
24	32	1.50085E-01	-4.58028E-01	5.37155E-01	-4.66709E-03	2.41412E-04	-1.04051E-02
25	26	2.54783E-03	-1.34486E-01	-1.10361E-01	6.02782E-03	7.40778E-03	-4.90696E-03
25	27	8.92657E-03	8.07038E-01	-1.94403E-01	-1.21608E-02	-1.02239E-02	-8.21863E-03
25	31	3.56815E-01	6.60644E-01	2.15483E-01	4.12352E-03	6.49189E-03	3.92855E-03
25	32	1.85408E-01	-1.73742E-01	1.96314E-01	9.63314E-03	-2.13488E-03	3.18312E-03
26	27	-3.50515E-01	2.57243E 00	-5.70627E 00	2.34173E-03	5.52826E-02	4.09769E-02
27	29	-6.00767E-02	-1.22796E-01	-9.86243E-02	5.43425E-03	1.41418E-03	-8.43088E-05
27	31	-1.47529E-01	-4.34768E-01	1.22681E-01	2.21990E-02	3.29837E-03	-2.89539E-03
27	32	-3.26980E-01	-2.44053E 00	5.70406E-01	1.70902E-02	-5.39820E-03	-1.97307E-02
20	28	1.28539E-01	-2.09100E-02	-1.74135E-01	2.45271E-02	2.41292E-03	5.08159E-03
4	35	2.16858E-03	-2.14926E-01	-3.67564E-01	-9.01091E-03	9.18579E-03	-2.20056E-02
5	36	2.12904E-03	-2.46318E-02	-3.79135E-01	2.39776E-03	9.83400E-03	3.52904E-03
20	29	1.17407E-01	1.76950E-01	-2.34907E-01	-1.29427E-02	8.39593E-03	2.84782E-03
20	33	-1.49664E-01	-2.28320E-03	-1.14694E 00	2.05893E-03	1.39006E-02	3.04510E-03
31	32	2.61224E-01	-5.87575E-02	-8.01947E-01	-1.02666E-05	9.72000E-03	9.24790E-06
31	33	-1.55922E-02	2.78944E-03	3.78300E-02	2.34292E-04	-5.88598E-04	1.87180E-04
31	34	2.99396E-02	7.73201E-03	9.08172E-02	-4.06060E-05	-1.59067E-03	1.04193E-04
33	34	1.17022E-03	1.07562E-02	7.97068E-02	2.22814E-04	-1.00244E-03	1.44921E-04

CH-47A POST TEST MODEL 36 NODES V=340,0,522 DEG=0,-8.7,0
TIME= .10399973

I,SC(I,1),SC(I,2),SC(I,3)

3	.00000E 00	.00000E 00	6.36024E-01
4	.00000E 00	.00000E 00	1.29599E 00
5	.00000E 00	.00000E 00	1.69183E 00
8	.00000E 00	.00000E 00	3.00522E-03
9	.00000E 00	.00000E 00	3.22361E-02

10	.00000E 00	.00000E 00	4.16316E-01
11	.00000E 00	.00000E 00	9.55347E-05
12	.00000E 00	.00000E 00	3.11070E-02
16	.00000E 00	.00000E 00	.00000E 00
17	.00000E 00	.00000E 00	.00000E 00
18	.00000E 00	.00000E 00	.00000E 00
22	.00000E 00	.00000E 00	.00000E 00
23	.00000E 00	.00000E 00	5.93158E 00
24	.00000E 00	.00000E 00	.00000E 00
25	.00000E 00	.00000E 00	.00000E 00
26	.00000E 00	.00000E 00	6.29259E 00
30	.00000E 00	.00000E 00	3.11536E-03
37	.00000E 00	.00000E 00	3.32217E-03

***** LINEAR MOMENTUM OF MOVING MASS AGGREGATE*****

SUMMVX	XDOTCG	SUMMVY	YDOTCG	SUMMVZ	ZDOTCG
1.58734E 04	2.44986E 02	9.87789E 01	1.52452E 00	1.17024E 04	1.80611E 02

***** ENERGY CALCULATIONS *****

	TOTAL ENERGY	KINETIC ENERGY	POTENTIAL ENERGY	STRAIN ENERGY	DAMPING ENERGY	CRUSHING ENERGY
	1.51600E 07	7.79908E 06	1.51407E 06	1.56531E 06	3.16196E 05	3.96535E 06
PERCENT OF TOTAL ENERGY		51.445	9.987	10.325	2.086	26.157

					INTERNAL BEAM							EXTERNAL SPRING			
MASS	KENETIC ENERGY	PER CENT	POTENTIAL ENERGY	PER CENT	IJ	I	J	STRAIN ENERGY	PER CENT	DAMPING ENERGY	PER CENT	I	K	CRUSHING ENERGY	PER CEN
1	1.50380E 05	1.926	1.67293E 05	11.049	1	1	2	4.49143F 03	.287	1.70936E 04	5.406	3	3	1.78135E 06	44.92
2	1.96871E 05	2.524	1.80378E 05	11.913	2	2	3	1.17271E 05	7.492	5.14995E 04	16.287	4	3	1.96931E 05	4.96
3	4.74071E 05	6.079	2.36520E 04	1.562	3	2	6	1.50749F 04	.963	2.49459E 03	.789	5	3	1.97100E 05	4.97
4	3.53861E 04	.454	3.79290E 03	.251	4	2	7	4.32038E 04	2.760	2.06713E 04	6.537	8	3	6.96217E 04	1.75
5	3.60075E 04	.462	3.72383E 03	.246	5	2	8	6.42486F 04	4.105	1.59068E 03	.503	9	3	4.28628E 05	10.80
6	3.07934E 04	.395	2.02925E 04	1.340	6	2	11	6.40951E 04	4.095	1.51710E 03	.480	10	3	5.72362E 05	14.43
7	1.99090E 04	.255	1.95585E 04	1.292	7	2	13	6.24035F 04	3.987	2.59215E 04	8.198	11	3	1.79783E 03	.04
8	1.62483E 05	2.083	8.75639E 03	.578	8	3	4	3.33695E 03	.213	7.51740E 03	2.377	12	3	4.25227E 05	10.72
9	1.55467E 05	1.993	2.64295E 03	.175	9	3	5	3.16451F 03	.202	7.42903E 03	2.349	16	3	.00000E 00	.00
10	3.21982E 05	4.128	1.04634E 04	.691	10	3	7	-1.00974E-01	-.000	8.90627E 01	.028	17	3	.00000E 00	.00
11	1.47440E 05	1.890	7.80118E 03	.515	11	3	8	4.74799F 04	3.033	2.83411E 04	8.963	18	3	.00000E 00	.00
12	1.76598E 05	2.264	3.08594E 03	.204	12	3	10	2.44552E 04	1.562	2.20806E 03	.698	22	3	.00000E 00	.00
13	5.11321E 04	.656	1.88956E 04	1.248	13	3	11	6.89503F 04	4.405	2.71439E 04	8.584	23	3	1.31670E 05	3.32
14	7.27871E 04	.933	2.02144E 04	1.335	14	3	13	-9.23753E-02	-.000	7.86058E 01	.025	24	3	.00000E 00	.00
15	2.85431E 04	.366	1.41165E 04	.932	15	6	7	3.66133E 03	.234	9.00372E 02	.285	25	3	.00000E 00	.00
16	3.71145E 05	4.759	1.38140E 04	.912	16	6	13	1.30165F 04	.832	4.68926E 02	.148	26	3	1.54608E 05	3.89
17	8.82042E 05	11.310	1.39499E 04	.921	17	6	14	1.87221E 04	1.196	4.57538E 02	.145	30	3	3.02518E 03	.07
18	4.02740E 05	5.164	1.01574E 04	.671	18	7	8	3.43071F 04	2.192	7.02755E 03	2.223	37	3	3.02689E 03	.07
19	3.53466E 04	.453	1.37573E 04	.909	19	6	15	7.45313E 02	.048	1.81400E 02	.057				

20	2.02144E 05	2.592	6.43150E 04	4.248
21	1.09560E 05	1.405	3.16276E 04	2.089
22	1.77224E 05	2.272	8.13664E 03	.537
23	4.78388E 04	.613	4.18145E 03	.276
24	8.42742E 05	10.806	2.77102E 04	1.830
25	1.96840E 05	2.524	7.89383E 03	.521
26	4.17339E 04	.535	4.09958E 03	.271
27	1.19661E 05	1.534	3.13964E 04	2.074
28	2.60830E 05	3.344	9.78124E 04	6.460
29	2.84676E 05	3.650	9.74296E 04	6.435
30	6.49652E 04	.833	7.93452E 03	.524
31	1.48852E 05	1.909	5.31847E 04	3.513
32	2.95139E 05	3.784	3.68934E 04	2.437
33	5.53787E 05	7.101	1.50527E 05	9.942
34	5.82691E 05	7.471	3.08007E 05	20.343
35	2.67237E 04	.343	9.36112E 03	.618
36	2.75407E 04	.353	9.27833E 03	.613
37	6.50023E 04	.833	7.93673E 03	.524

20	7	15	5.14995E 04	3.290	5.59938E 03	1.771
21	8	9	2.54650E 04	1.627	3.82190E 02	.121
22	8	10	1.83269E 04	1.171	3.12297E 02	.099
23	7	16	4.32181E 04	2.761	5.77566E 02	.183
24	8	16	1.70609E 05	10.899	1.27984E 04	4.048
25	8	30	2.51869E 02	.016	5.45327E 00	.002
26	10	18	4.11694E 02	.026	1.78231E 03	.564
27	10	11	3.70541E 04	2.367	1.29830E 04	4.106
28	10	17	6.18263E 02	.039	8.33299E 02	.264
29	11	12	3.97507E 04	2.539	3.83084E 02	.121
30	11	13	8.16962E 03	.522	2.64298E 03	.836
31	10	16	1.56157E 02	.010	1.74851E 03	.553
32	11	18	1.76183E 05	11.255	1.04891E 04	3.317
33	11	37	2.52394E 02	.016	5.51741E 00	.002
34	13	18	4.28553E 04	2.738	6.22368E 02	.197
35	6	19	5.61764E 02	.036	4.63609E 02	.147
36	13	19	4.11205E 04	2.627	4.67405E 03	1.478
37	14	15	1.15400E 03	.074	2.19434E 02	.069
38	14	19	3.00132E 03	.192	3.28833E 02	.104
39	14	20	4.43885E 03	.284	5.29917E 02	.168
40	14	21	9.77665E 02	.062	1.88445E 02	.060
41	14	27	2.41126E 03	.154	2.19931E 02	.070
42	15	16	6.07783E 03	.388	5.95965E 02	.188
43	15	21	4.31519E 04	2.757	2.43570E 03	.770
44	15	22	1.41775E 03	.091	4.29705E 02	.136
45	16	17	6.80096E 03	.434	2.41120E 03	.763
46	16	22	4.88914E 04	3.123	7.96916E 03	2.520
47	17	18	5.85955E 03	.374	4.10019E 03	1.297
48	17	22	2.62708E 01	.002	1.73683E 03	.549
49	17	24	3.83198E 03	.245	4.55822E 02	.144
50	17	25	6.39201E 02	.041	7.10295E 02	.225
51	18	19	2.19386E 03	.140	2.64391E 03	.836
52	18	25	5.44860E 04	3.481	6.47474E 03	2.048
53	19	25	2.74016E 00	.000	8.42769E 02	.267
54	19	27	4.63518E 04	2.961	3.63772E 03	1.150
55	20	21	1.41816E 03	.091	2.22203E 02	.070
56	20	27	2.41266E 03	.154	3.04137E 02	.096
57	20	31	1.60533E 03	.103	5.69382E 01	.018
58	21	22	2.16196E 03	.138	2.69857E 02	.085
59	21	23	6.03477E 03	.386	1.81124E 02	.057
60	21	28	2.18246E 03	.139	8.38611E 02	.265
61	21	31	2.74143E 03	.175	6.02104E 02	.190
62	21	32	2.00082E 03	.128	1.08905E 02	.034
63	22	23	4.55699E 02	.029	2.23441E 02	.071
64	22	24	4.66941E 03	.298	1.12768E 03	.357
65	22	31	2.40187E 03	.153	1.17448E 02	.037
66	22	32	1.75681E 03	.112	1.04869E 03	.332
67	24	25	3.40276E 03	.217	1.01377E 03	.321
68	24	32	8.29988E 02	.053	1.29435E 03	.409
69	25	26	3.69155E 02	.024	2.21321E 02	.070
70	25	27	5.43143E 02	.035	2.75007E 02	.087
71	25	31	5.71173E 03	.365	1.63642E 02	.052
72	25	32	5.15944E 03	.330	8.65362E 02	.274
73	26	27	7.06080E 03	.451	1.61355E 02	.051
74	27	29	2.39775E 03	.153	9.31175E 02	.294
75	27	31	2.05032E 03	.131	6.80240E 02	.215
76	27	32	4.96245E 03	.317	2.16640E 02	.069
77	20	28	3.93106E 03	.251	6.98804E 02	.221

78	4	35	2.27146E 03	.145	3.79212E 03	1.199
79	5	36	1.87842E 03	.120	3.76738E 03	1.191
80	20	29	2.83798E 03	.181	7.36458E 02	.233
81	20	33	2.90741E 03	.186	3.71934E 02	.118
82	31	32	1.09080E 04	.697	6.79135E 02	.215
83	31	33	2.37530E 02	.015	2.68791E 01	.009
84	31	34	1.13368E 03	.072	1.46197E 02	.046
85	33	34	3.50853E 01	.002	1.88583E 02	.060